PLAN OF OPERATIONS

Geothermal Development Activities

(Exploration Phase)

Kilauea Middle East Rift Zone

Estate of James Campbell Property TMK 1-2-10:3

True/Mid-Pacific Geothermal Venture

January, 1989

Encl (1) to
LTR to Chairman,
BLNR
dtd _____

(26)

TRUE GEOTHERMAL ENERGY COMPANY

895 WEST RIVER CROSS ROAD

Phone (307) 237-9301
P.O. Box 2360
Casper, Wyoming
82602

February 1, 1989

Mr. William W. Paty, Chairman
State Board of Land & Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Subject: Plan of Operations for Geothermal Exploration Drilling in the Kilauea Middle East Rift Zone (KMERZ)

Dear Mr. Paty:

The subject Plan of Operations, Enclosure (1), is submitted for approval as directed by the Board of Land & Natural Resources Decision and Order (D&O) of April 11, 1986, on Campbell Estate's application for a land use permit on their land parcel on the Island of Hawaii, Puna District, TMK 1-20-10:3. The Plan of Operations was prepared in accordance with DLNR Administrative Rules, Chapter 183, Section 13-183-55.

The Plan of Operations provides the framework for conducting the level of geothermal exploration activities authorized in the D&O including information on the physical, geographical and geophysical aspects of the project site, resource potential and non-drilling operating procedures. The data required on drilling operations and procedures has been included in the Application For Permit to Drill a Geothermal Well, submitted under separate cover to DLNR in accordance with DLNR Administrative Rules, Chapter 183, Section 13-183-65.

Data requirements for the Board's Decision and Order prescribed environmental monitoring plans and programs for the exploration of the project are submitted under separate cover to the Department of Land & Natural Resources for ministerial approval as provided in the Decision and Order. In addition, the D&O required that the noise monitoring plan, the biological survey report and the emergency plan be submitted to the County of Hawaii for review and comment. The air quality monitoring plan has also been submitted to the Director of Health, State of Hawaii Health Department, for approval as a matter under cognizance of that department. Concurrently, the Application for Authority to Construct (ATC) twelve geothermal exploration wells has been submitted to the Health Department for approval as a matter relating to air quality control.

Upon completion of sufficient exploration to support proceeding with development activities and upon evidence that a market exists on the Island of Hawaii for up to 25 MW of power, a Development Plan will be submitted to DLNR for approval to proceed with the applicable level of development. Additional Development Plans will be submitted for increments of development up to 75 MW (for a total of 100 MW) as the market for such power is established locally or on Oahu via deepwater transmission cable. Development beyond 100 MW would require a supplemental CDUA.

The preliminary schedule of project activity is included in the Plan of Operations.

Campbell Estate has reviewed and concurs in the Plan of Operations.

Very truly yours,

TRUE GEOTHERMAL ENERGY COMPANY
(Operator for True/Mid-Pacific
Geothermal Venture)

H.A. True, III, Partner

Encl: 1) Plan of Operations

cc: Mid Pacific Geothermal, Inc.
Estate of James Campbell

PLAN OF OPERATIONS

Geothermal Development Activities

(Exploration Phase)

Kilauea Middle East Rift Zone

Estate of James Campbell Property TMK 1-2-10:3

True/Mid-Pacific Geothermal Venture

January, 1989

Encl (1) to
LTR to Chairman,
BLNR
dtd _____

(Plan of Operations)

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LIST OF FIGURES

PLAN OF OPERATIONS

Geothermal Project for the Kilauea Middle East Rift Zone, Puna District, Island of Hawaii (Campbell Estate Property, TMK: 1-2-10:3)

INTRODUCTION:

This plan of operations includes the map and data requirements for geothermal exploration activities as prescribed in Section 13-183-55, Chapter 183, DLNR Administrative Rules on Leasing and Drilling of Geothermal Resources, and the Decision and Order, (D & O), Board of Land and Natural Resources, dated April 11, 1986.

The environmental monitoring plans and programs including the Management Plan, the Emergency Plan and procedures on abated venting are submitted separately to DLNR for administrative approval as directed in the Board's Decision and Order. In addition, the Noise Monitoring Plan, the Biological Survey Report and the Emergency Plan are submitted concurrently to the County of Hawaii for Review and comment.

The initial exploration drilling activities to be undertaken within the scope of the Plan of Operations are described in Section II of the Final Supplemental Environmental Impact Statement for this project (February 1986) and subject to conditions imposed in the Board's Decision and Order. Additional exploration drilling will be conducted for the purpose of further determining, in conjunction with earlier drilling, the location and extent of

geothermal resources within the project area (geothermal resource sub-zone) and whether such resources could be economically developed and sufficient to produce and sustain the production of 100mw of geothermal generated electricity for 30 years.

Changes to the Plan of Operations will be requested as may be necessary due to the results of continuing drilling operations, natural phenomena, and cumulative environmental monitoring which establish the need to make adjustments in operating procedures, project impact mitigation measures and environmental monitoring plans and programs.

Following the completion of sufficient exploration activities to prove the existence of economically producible resources and upon negotiation of a power purchase contract with an electrical consumer, a Development Plan for the contracted amount of power (up to 25mw) together with required changes to the Plan of Operations will be submitted for approval.

It is expected that development of geothermal generated electrical energy will occur in increments up to a total of 100mw, the limit imposed under the current Conservation District Permit of April 11, 1986.

1. Exploration Drilling Program and Schedule

   a. The exploration drilling program including the planned sequence for drilling exploration wells within the project site is described in the Application for Permit to Drill submitted to DLNR in accordance with Section 13-183-65, Chapter 183, DLNR Administrative Rules on Leasing and Drilling of Geothermal Resources.

   b. Activity Schedule. (See Figure 1.)

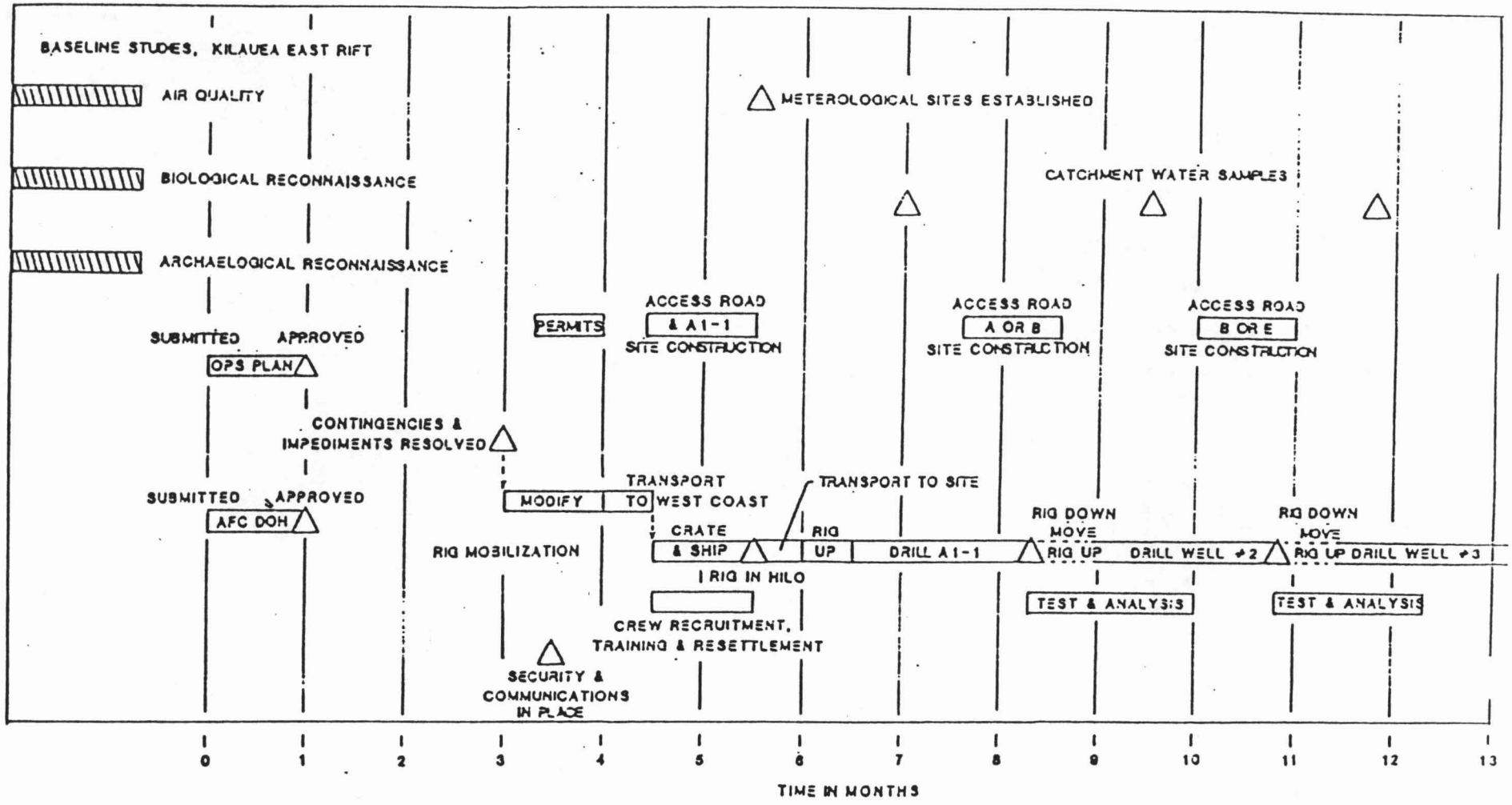
2. Project Area/Drilling Site Description

   a. The project site is located along the Kilauea middle east rift zone, Island of Hawaii, Puna District, within a geothermal resource sub-zone covering an area of about 9,000 acres within Campbell Estate Property, TMK 1-2-10:3.

   b. Drilling Site Designation: True/Mid-Pacific A1 (TMP A1).

   c. Topographic features of the project site including the location of the first exploration drilling site (A1) are as shown on Figure 2. The principal topographic feature within the project site is Pu'u Heiheiahulu, located about 7,000 feet south of drilling site A1.

   d. Metes and bounds description of Drilling site A1. (See Attachment 1); As a result of the findings reported in the biological survey of proposed drilling site A1, it has been determined that by relocating the drill site 300 feet east of the position shown on Figure 2, the clearing of a portion of an 'Ohi'a class a-(2) forest which contains a resident population of a native bird (not endangered), the Hawai'i 'elepaio, can be avoided. Accordingly, the adjusted surveyed location of drilling site A1 is as indicated in Attachment 1.



REVISED	DATE

TSI Thermal Source Inc. 100 E Street • P.O. Box 1236 • Santa Rosa, California 95402

ACTIVITY SCHEDULE
(True/Mid-Pacific Geothermal Project)

FIGURE 1

e. Size and Configuration: Each drilling site will cover approximately 5 acres including 1 acre for a water catchment pond when required. (See Figure 3, Plot Plan).

f. Planned Excavation and Grading:

The access road to drilling site A1 which has been surveyed and staked as shown on Figure 4, will be graded as a 20 ft. wide construction road along the alignment shown. Due to the gradual slope of the project area, cut and fill requirements will be limited. The depth of any cut is not expected to exceed 20 ft. At the drilling site, the area will be cleared and graded to accommodate the drill rig and ancillary equipment as identified in the drilling site plot plan, Figure 3. A sump for well effluent will be excavated adjacent to the drill rig as shown on the plot plan. Dimensions of the sump will be approximately 120' by 360' by 10'. In addition, a site for a water catchment pond will be excavated adjacent to the drilling site. Dimensions for the water catchment pond are approximately 200' by 300' by 10'. Excavated materials will be retained on site for future use or refill of the sump or pond.

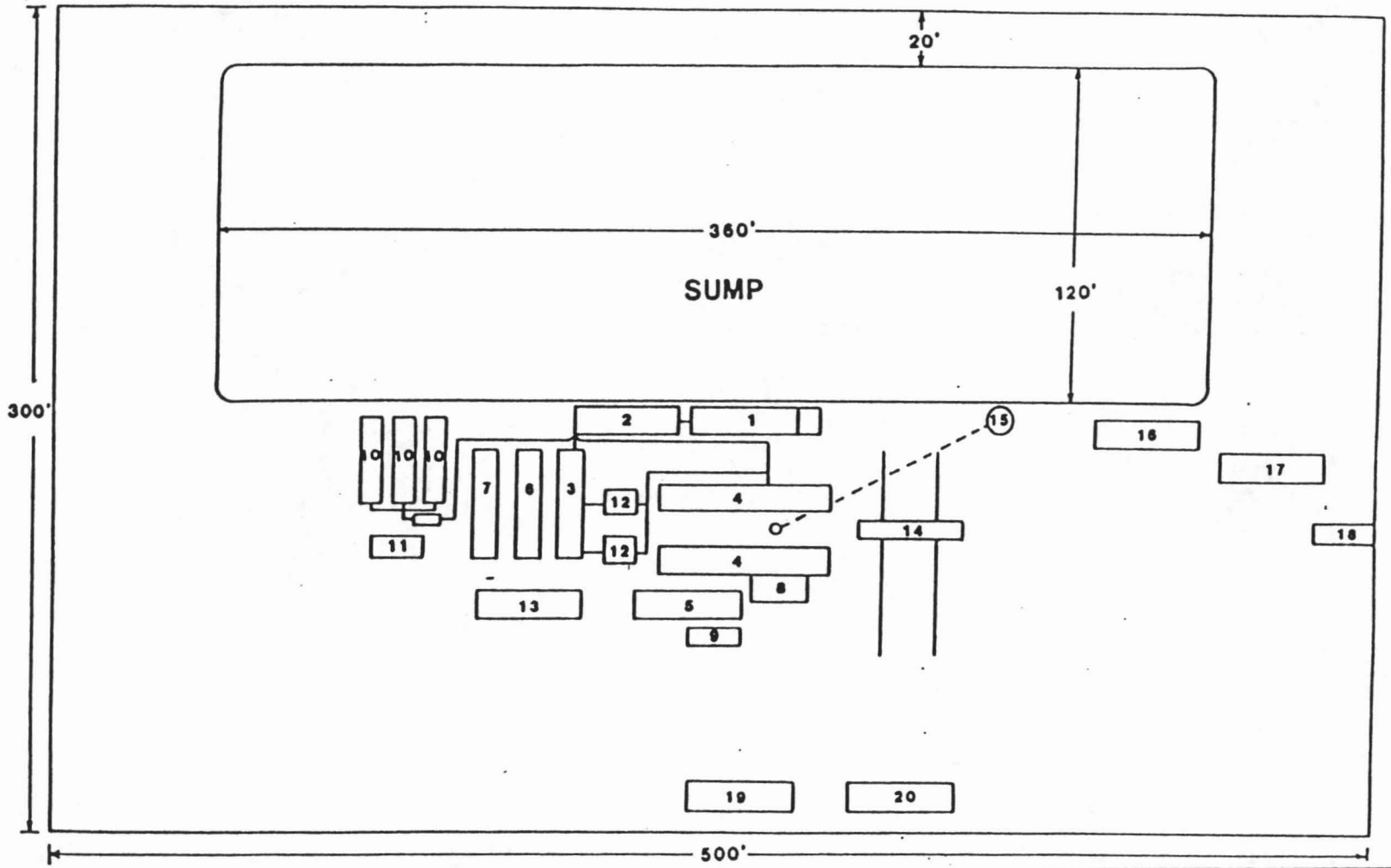
g. Elevation of Drilling Rig Above Sea Level.

1,500 ft.

3. Well Bore

a. Well Designation Number: True/Mid-Pacific A1-1

b. Location Within Drilling Site: (See Figure 3)



1. Mud tank with slug pit
2. Mud tank
3. Mud tank
4. 2-Subbases
5. Generator house
6. Water tank
7. Fuel tank
8. Dog house
9. Accumulator
10. 3-Air compressors for air drilling
11. Compressor operator's trailer
12. 2-Mud pumps
13. Cementing unit
14. Cat walk with pipe racks
15. Muffler for air drilling
16. Abatement equipment
17. Mud logger's trailer
18. Electric logging unit
19. Part house/change room
20. Tool pushers' trailer

TSI
THERMASOURCE

PLOT PLAN
(True/Mid-Pacific Project)

FIGURE
3

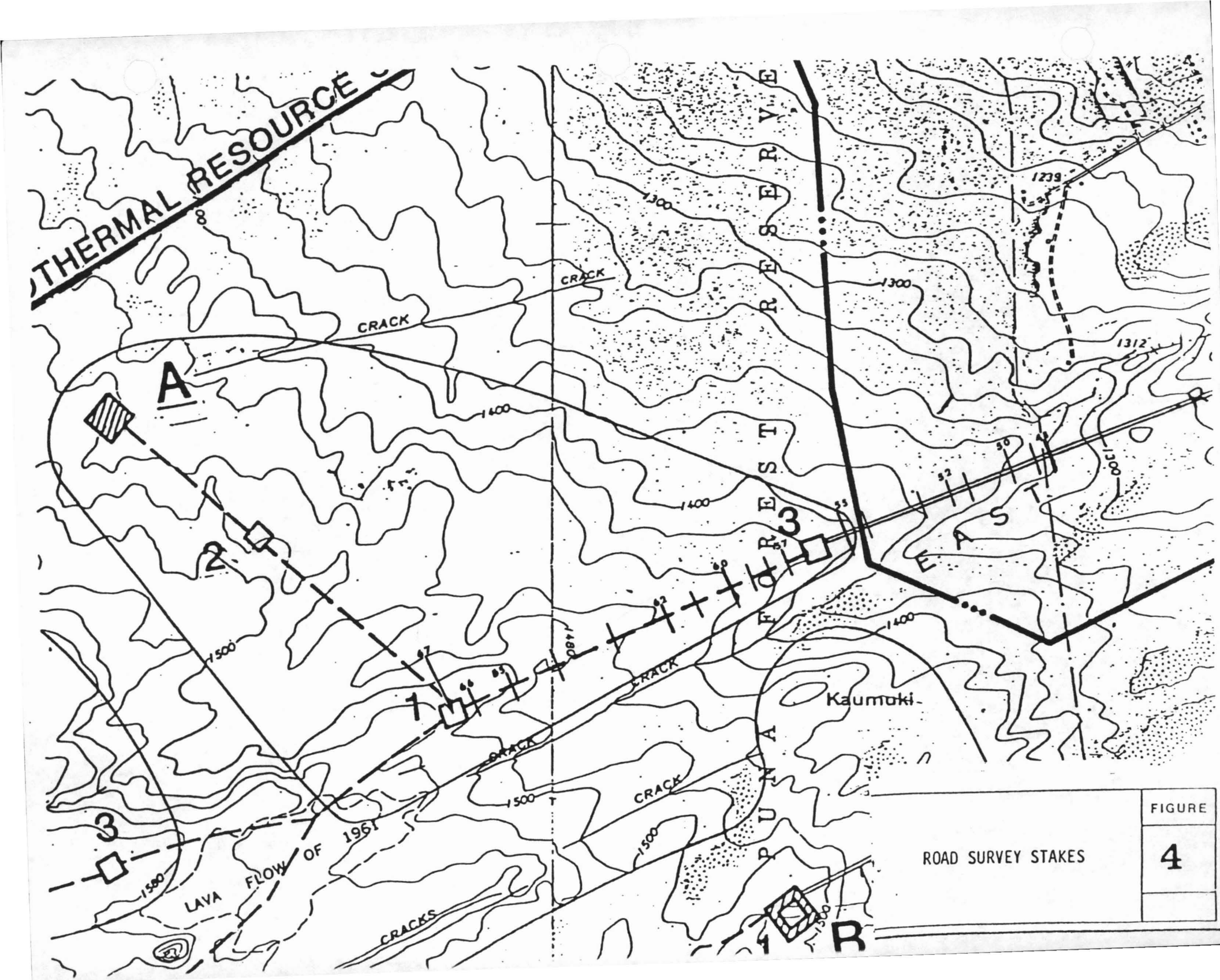


FIGURE 4

ROAD SURVEY STAKES

c. Proposed Depth of Resource Discovery and Bottom Hole Location: It is expected to encounter a geothermal reservoir beginning at a depth of 4,500 ft. Total depth is expected to be in the range of 8,000 - 14,000 ft., true vertical depth.

d. Description of Drilling and Casing Program and Proposed Well Completion and Testing Program: (Contained in Application for Permit to Drill a Geothermal Exploration Well).

4. Planned Access and Lateral Roads

a. Location (See Figure 2)

(1) The primary route to the project site will be via State Road 130 to the Pahoa by-pass road north of Pahoa, to South Road to Kaohe Homesteads to Middle Road and south along State Road easement (20 ft. width) to the boundary of the Campbell Estate property (TMK 1-2-10:1). The easement for the State Road was granted by Department of Land and Natural Resources letter of January 16, 1987 to the Estate of James Campbell.

(2) The planned access road to the first drilling site (True/Mid-Pacific A1) is shown on Figure 1. However, as a result of the findings of the biological survey of the proposed access road alignment, the sighting of three trees being considered for listing by the U.S. Fish and wildlife Service as endangered species (Bobea timonioides and Tetraplasandra), it has been decided to deviate the access road east of survey stakes #48 and #58 (Figure 4) to avoid these trees as shown in Attachment 1.

(3) Three turn-outs along the road will be selected after grubbing is completed and shown on a revised map. Grubbing will extend to 10 feet on each side of the bed. The initial width of the access road will be 20 ft. Segments of the road where cut and fill is required will be widened to 30-40 ft. During the development phase, the access road will be widened to 30 ft.

(4) A grubbing permit has been requested from the County of Hawaii for the access road including the unimproved portion of the State road easement. Application for a grading permit will be made to the County of Hawaii subsequent to completing the grubbing and engineering design.

(5) The location of planned lateral roads to subsequent drill sites are as shown in Figure 5, Exploration and Development Plan for the Project.

b. Metes and Bounds Description of the Access Road (Attachment 1)

c. Metes and Bounds of lateral roads and other drilling sites will be submitted together with required pre-clearing survey data when such sites and road alignments are determined.

d. Access Control (Described in the Management Plan, submitted separately to DLNR).

5. Source of Water Supply and Road Building Materials

a. Potable water for drinking, sanitation and for work force safety measures will be trucked in to the project site from an existing county water point.

The primary water source for drilling and testing operations and fire fighting will be catchment water. Every attempt will be made to recycle all water used in drilling and testing operations. A water catchment site with a total capacity of 500,000 to 1,000,000 gallons will be located adjacent to each drilling site when required. The catchment pond will be supplemented initially with water trucked in from the county water point. (During the development phase, plans may include the installation of a water pipeline from a nearby well.) Condensate from power plant operations will provide replacement water for the cooling tower system during the development phase as will be described in the future development plan.

b. During the initial exploration phase of the project, it is expected that only road topping cinders will be needed from outside of the project site. Off-site materials will be required in the development phase to widen and improve the access road.

6. Major Project Facilities/Equipment for Drilling Activities

a. The major project facilities and equipment for the exploration phase are the drilling rig and ancillary equipment including utility

vehicles, pumps, generators, compressors, drill pipe racks, and tanks for water, drilling mud and fuel. In addition, a sump for well effluent and a water catchment pond will be required.

b. This equipment will be arranged around the drilling rig, approximately as shown in Figure 3.

7. Other Areas of Potential Surface Disturbance

Figure 5 identifies the planned facility sites and connecting roads within the project area which may be used during the progression of project exploration and development activities depending on the extent and location of discovered geothermal resources and market demand for geothermal energy.

Field surveys will continue to be made of any of the areas to be occupied for project activities prior to clearing or construction and results reported to DLNR for review and approval.

8. Disposal Procedures for Well Effluent/Other Wastes

a. During the exploration phase, project wastes such as drilling effluent (cuttings from the well bore, drilling mud and fluids) will be discharged into a sump at each drilling site. Solids will be settled out and fluids will be recycled. Residual solids will be left in the sump and buried, or in the case of drill cuttings, used as sand within the drill site if needed. Similarly, geothermal brine brought to the surface during well testing will be piped to a rock muffler and then discharged into a sump for percolation. In

the unlikely event that fresh ground water is found to exist in the rift zone at the project site and it is determined that the limited amount of brine produced from the well would contaminate the fresh water a lined sump will be used for collecting of the brine for settling out of solids. Trash will be collected daily on site and

periodically transferred to the nearest county disposal site. Portable toilets will be positioned on site.

9. Narrative Statement Describing the Proposed Measures to be Taken for the Protection of the Environment

As described in Section 6 in the Revised Environmental Impact Statement for Kahauale'a, June 1982, Section III in the Final Supplemental EIS to Revised EIS for Kahauale'a, February 1986, and in the environmental monitoring plans and programs submitted separately to DLNR for ministerial approval.

10. Geologist's Preliminary Report on Surface and Sub-Surface Geology, Nature and Occurrence of the Known or Potential Geothermal Resources, Surface Water Resources and Ground Water Resources.

a. Geothermal resources in the Kilauea Middle East Rift Zone (KMERZ)

The resource potential of the Kilauea East Rift Zone has been recognized for many years and studied by many investigators. The combination of a prolific heat source, abundant water, and permeable rocks at drillable depths makes the East Rift Zone a highly valued resource area.

There is no fundamental change in surface geology along the 30 mile extent of the East Rift Zone. The proposed development will occur in the area of the Middle East Rift Zone as shown on Figure 5. Variations in surface geology are determined by the number and density of surface vents and faults, the age of the lava flows, and the variations between a'a-a'a and Pahoehoe flows.

Stratigraphy of the KMERZ is simple in that all the rocks are basaltic lavas. Seismicity caused by magma movement and thermal contraction after intrusion is believed to induce the fracturing that is necessary for creating a geothermal reservoir. Approach of the drill bit into a reservoir will be indicated by marked increases in temperature.

Temperatures and pressures are expected to be similar to that encountered at H.G.P.A. It is also expected that a liquid dominated reservoir will be encountered.

The HGP-A Project proved that the Kilauea east rift was a commercial geothermal province. Moreover, it demonstrated that wells could be drilled, tested, and produced with existing technology. Six additional deep geothermal wells have been drilled in the lower east rift zone. Of the seven total wells, two are producers, two produced geothermal fluids but had mechanical failures, and three wells did not encounter sufficient fracture permeability to produce

geothermal fluids. Based on this result, it is apparent that success or failure hinges on the existence of fractured rocks at the target depths. Temperatures are not an overriding concern. In fact, an aeromagnetic survey reported by Godson (1981) suggests that temperatures under the Middle East Rift Zone are quite adequate for geothermal development. The apparent negative magnetism suggests subsurface rock temperatures that are above the Curie temperature of 500 degrees C.

Thus, to determine favorable areas to encounter permeability, several techniques are feasible including evidence of micro earthquakes,: surface geology, radon surveys, and exploratory drilling. The latter is the most definitive. Surface geology was meaningful in the siting of the Kapoho State Wells (Iovenitti, 1985). An apparent offset in the rift zone was one of the primary justifications for the well sites. Geothermal exploration in other magmatic environments such as the Phillipines, Alaska, and Long Valley Caldera utilizes surface geological features in drill site selection, and considerable reliance will be placed on surface geology in the KMERZ.

Radon is a naturally occurring radioactive gas that emanates from geothermal systems. Thus, if radon is detected at the surface and particularly near faults or vents, this suggests a geothermal fluid may be close by or may have been close by. Cox (1980) did a passive radon survey from Kaohe Homesteads to Cape Kumakahi. This survey

delineated a radon anomaly that was elongated along the axis of the rift zone but with a very irregular shape. Interestingly, all three wells that failed to encounter geothermal fluids were drilled outside the radon anomaly. All four productive wells were drilled within the anomaly. The radon anomaly comes up to the boundary between Kaohe Homesteads and the Puna Forest Reserve suggesting a high degree of probability that a geothermal resource extends into the proposed development area. At the boundary, the radon anomaly is 3 Km wide and stretches across the rift zone from about Iilewa Crater to the northwest corner of Kaohe Homesteads.

Recently, reports in the literature (Iovenitti, 1985) have indicated that the Kapoho State Wells #1 and #2 have produced dry steam. If true, the resource description may have to be altered to take this into account. Although the reservoir is liquid-dominated, there may be areas dry steam is present. If in fact the produced fluid is dry steam, it will be a much easier task to produce, transport, utilize, and dispose of the geothermal fluids. However, plans for drilling and development anticipate a two-phase resource.

A Statewide Geothermal Resource Assessment (DLNR, 1984) concluded that the proposed development area has high geothermal potential. In fact half of the development area has a probability of 90% or greater of encountering a resource with temperatures above 125 degrees C. The other half has a 25% to 90% probability of encountering the same type of resource.

Within the proposed development area, recent lava flows have occurred in 1961, 1963, 1977, and 1985. Steaming ground at Heiheiahulu has also been reported indicating that a heat source is in the vicinity.

Information about the proposed development area indicates that there is a high probability that a resource will be discovered which is sufficient evidence to justify exploratory drilling. See Appendix D to Revised Environmental Impact Statement for Kahauale'a (June 1982) and DLNR Report 1985.

b. Surface & Ground Water Resources

There are no known surface streams or natural water storage features in the project area. There are pockets of standing water in areas underlain by Pahoehoe lava in the North eastern portion of the project area which includes the access road to the first drill site.

Ground water along the Kilauea east rift may occur as dike impounded, perched and basal water. According to the State's report on Geothermal Resource Subzones (DPED, June 1986) "the only known perched water exists north of Mountain View", and "Basal water underlies all of the Kilauea east rift zone except where dikes occur."

It is expected that all basal water in this area will be at elevated temperatures with saline content varying from low (north side of rift zone) to high (south side of rift zone) and therefore the water will not be potable. This condition is evidenced in the lower portions of the rift zone by samples of well water on the North and South sides of the rift zone and within the rift zone. Analysis of water samples taken before injection of production well effluent will be used to verify that the basal water in the middle rift zone is non-potable as has been observed in the lower rift zone.

11. Environmental Monitoring Plans and Programs

The D & O prescribed environmental monitoring plans and programs are submitted separately to DLNR for ministerial approval.

12. Development Plans

(Plans for the development of a discovered resource will be submitted to DLNR for approval when it has been determined that such resources are suitable for production and a demand for the energy at a specified level has been established.)

Metes and Bounds Description

Access Road and Drilling Site for Geothermal Development Activities

Kilauea Middle East Rift Zone,

Campbell Estate Property TMK 1-2-10:1

and TMK 1-2-10:3

State of Hawaii Easement, Kaohe Homesteads

Designated HST Plat 804

Attachment 1
Plan of Operations

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

GEOTHERMAL WELL DRILLING PERMIT

True/Mid-Pacific A1-1

TO: True Geothermal Energy Company
P.O. Box 2360
Casper, Wyoming 82602

Your application, dated February 1, 1989, for a permit to drill a geothermal well as follows, on lands included in State of Hawaii, Department of Land and Natural Resources, Geothermal Resources Mining Lease No. R-5, is approved:

Well Designation: True/Mid-Pacific A1-1
Location: TMK 1-2-10:03, Puna, Hawaii
Leased to: Estate of James Campbell (GRML R-5)
Subleased to: True/Mid-Pacific Geothermal Venture
Operator: True Geothermal Energy Company
Ground Elevation: 1,500 ft.±
Total Depth: 8,000 to 14,000 feet (maximum)

You are hereby granted permission to drill the geothermal well described above and in your application in accordance with the Department's Administrative Rules, Chapter 13-183, and the following conditions:

(1) All work shall be performed in accordance with the permission and terms of the occupier of the land, the Drilling and Completion Procedures submitted with your application, the Department's Administrative Rules (Chapters 13-183 and 13-184), and all other applicable Federal, State, and County laws, ordinances, rules and regulations;

(2) The applicant, its successors and assigns, shall indemnify and hold the State of Hawaii harmless from and against any loss, liability, claim or demand for property damage, personal injury and death arising out of any act or omission of the applicant, assigns, officers, employees, contractors and agents under this permit or relating to or connected with the granting of this permit;

(3) If any unanticipated sites or remains of historic or prehistoric interest (such as shell, bone, or charcoal deposits, human burials, rock or coral alignments, paving, or walls) are encountered during the operation, the applicant shall stop work and contact the Historic Preservation Office at 548-7460 or 548-6408 immediately;

(4) The applicant shall observe and comply with all valid requirements of County, State, and Federal authorities, and regulations pertaining to the lands and permittee's operations including, but not limited to, all water and air pollution control laws, and those relating to the environment;

(5) The applicant shall observe and comply with all requirements and conditions as set forth in the Board of Land and Natural Resources' Decision and Order dated April 11, 1986;

(6) If there are any contemplated changes in the proposed drilling program, the applicant shall obtain the Chairperson's approval prior to the execution of any such contemplated changes of work;

(7) The applicant shall file with the Chairperson prior to the start of the permitted activity, indemnity bonds as required under the Department's Administrative Rules, Sections 13-183-34 and 13-183-68;

(8) The well shall be located more than 100 feet from the outer boundary of the parcel of land on which the well is situated, or more than 100 feet from a public road, street, or highway dedicated prior to the commencement of drilling unless modified by the Chairperson upon request;

(9) No well shall be sited within 3,500 feet of the eastern boundary of the property line near Kaohe Homesteads, nor within 3,500 feet of the southeastern boundary of the property line near upper Kaimu Homesteads;

(10) When drilling has reached a depth of not more than 50 feet below sea level, the Department's representative shall be notified with reasonable time allowed for travel to the site, to obtain a representative groundwater sample and to measure the static water level;

(11) The drilling permit shall be valid for a period of one year from the date of issuance;

(12) The applicant shall submit to the Chairperson, the results of the exploration, all drilling and testing records, date of completion, and a survey of the well location by a Hawaii licensed surveyor within 30 days after completion of the well;

(13) The applicant shall notify the Division of Water and Land Development, in writing, of the date of the start of work;

(14) During use of the well for testing, monitoring and/or production purposes, the well and site shall be properly maintained until the well is plugged and abandoned in accordance with Administrative Rules, Chapter 13-183;

(15) The site shall be restored as near as possible to its original condition after operations are completed.

WILLIAM W. PATY, Chairperson
Board of Land and Natural Resources

MAY 30 1989
Date of Permit

cc: Land Board Members
Hawaii County Planning Dept.
Land Management Division
DBED
Department of Health
OEQC
OCEA
Allan Kawada

TRUE GEOTHERMAL ENERGY COMPANY

895 WEST RIVER CROSS ROAD

Phone (307) 237-9301
P.O. Box 2360
Casper, Wyoming
82602

February 1, 1989

Department of Land & Natural Resources (DLNR)
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Subject: Application for Permit to Drill a Geothermal Well in the Kilauea Middle East Rift Zone (KMERZ)

Dear Sirs:

The subject application, Enclosure (1), is submitted for approval in accordance with DLNR Administrative Rules, Chapter 183, Section 13-183-65.

The Application For Permit to Drill contains the detailed operating procedures and technical aspects that are involved in the drilling of a geothermal well, including well completion procedures, well testing, reservoir evaluation, exploration strategy designed to determine the location, characteristics and extent of geothermal resources in the project site, monitoring and abatement of H_2S at the well site, and acknowledgment of indemnity, bonding, insurance and other administrative requirements placed on the operator for the resource exploration and development phase of that project.

The rights to conduct geothermal mining operations within the designated geothermal resources subzone that encompasses portions of Campbell Estate lands in the Kilauea Middle East Rift Zone were granted to the Estate of James Campbell by State geothermal mining lease No. R-5 issued on July 23, 1987. By sublease agreement dated December 3, 1986, Campbell Estate has assigned its current and future mining lease rights to True Geothermal Energy Company and Mid-Pacific Geothermal, Inc. (True/Mid-Pacific Geothermal Venture) with True Geothermal Energy Company acting as the "operator" for all activities related to the exploration and field development of geothermal resources.

The Board of Land & Natural Resources authorized in its Decision & Order of April 11, 1986, the drilling of exploration and development wells sufficient to locate and develop geothermal resources capable of producing 100 MW of electricity. Subsequent applications for permit to

drill additional wells will be submitted periodically as the location of well sites is determined. Permission is requested to submit only new data for each subsequent application for permit to drill.

Very truly yours,

TRUE GEOTHERMAL ENERGY COMPANY
(Operator for True/Mid-Pacific
Geothermal Venture)

H. A. True, III, Partner

Encl: 1) Application For Permit to Drill

cc: Mid-Pacific Geothermal, Inc.
Estate of James Campbell

Application for Permit to Drill

Geothermal Development Activities

(Exploration Phase)

Kilauea Middle East Rift Zone

Campbell Estate Property TMK 1-2-10:3

True/Mid-Pacific Geothermal Venture

January, 1989

Enclosure (1),
Ltr to DLNR,
dtd_____

Application For Permit to Drill a Geothermal Well

(Campbell Estate Parcel, Puna District, Island of Hawaii, TMK 1-2-10:3)

1. Regulatory Requirements

This application for Permit to Drill a Geothermal Well is submitted in accordance with the Department of Land and Natural Resources (DLNR) Rules on Leasing and Drilling of Geothermal Resources, Title 13, Chapter 183, Paragraph 65. The information on drilling operations required in the Plan of Operations is included and combined with like requirements in the Application for Permit to Drill as described below.

Since all geothermal wells will be drilled generally in the same manner, most of the data in this Application will be applicable to all wells. Therefore, subsequent applications for a Permit to drill will include only new information applicable to the well to be drilled and any modifications to the current generic data applicable to all wells.

2. Applicant and Lease Provisions

The applicant is True Geothermal Energy Company, the Operator for True/Mid-Pacific Geothermal venture for the mining operations permitted under State Geothermal Mining Lease No. R-5 dated July 23, 1987 and issued to the Estate of James Campbell, Lessee. By Sub-lease Agreement between Campbell Estate and

KA1-1

True Geothermal Energy Company and Mid-Pacific Geothermal, Inc., dated December 3, 1986, Campbell Estate assigned its rights to True/Mid-Pacific Geothermal Venture to drill for, produce and take geothermal resources from the lands leased under any state mining lease issued to Campbell Estate on the lands described in the sublease. By Operating Agreement between True Geothermal Energy Company and Mid-Pacific Geothermal, Inc., dated October 5, 1982, True is designated as "Operator" and Mid-Pacific as "Non-Operator" for the geothermal venture. The operator is responsible for all drilling operations under the terms and conditions of the mining lease. Agent for the operator is Mr. Allan Kawada whose address is: True Geothermal Energy Co., 888 Mililani Street, 8th Floor, Honolulu, Hawaii 96813-2918, Tel: 528-3496. The organization of the operator is shown in Figure 1.

3. Well Identification

Geothermal wells to be drilled in the Kilauea middle east rift zone (KMERZ) under Mining Lease No. R-5 will be identified in relation to: one of the Planned Exploration/Development Areas (A through E) as shown on Figure 2; the drilling site number; and, the sequential number of each well drilled at a particular site. Under this procedure, the first well for which this application is submitted, is designated as True/Mid-Pacific Exploration/Development Area A, Drilling Site 1, Well No. 1, or True/Mid-Pacific A1-1.

4. Purpose and Objective of Proposed Work

The purpose of the proposed work is to explore for geothermal resources by

KA 1-(

Operator For Resource Exploration & Development

PROJECT ORGANIZATION

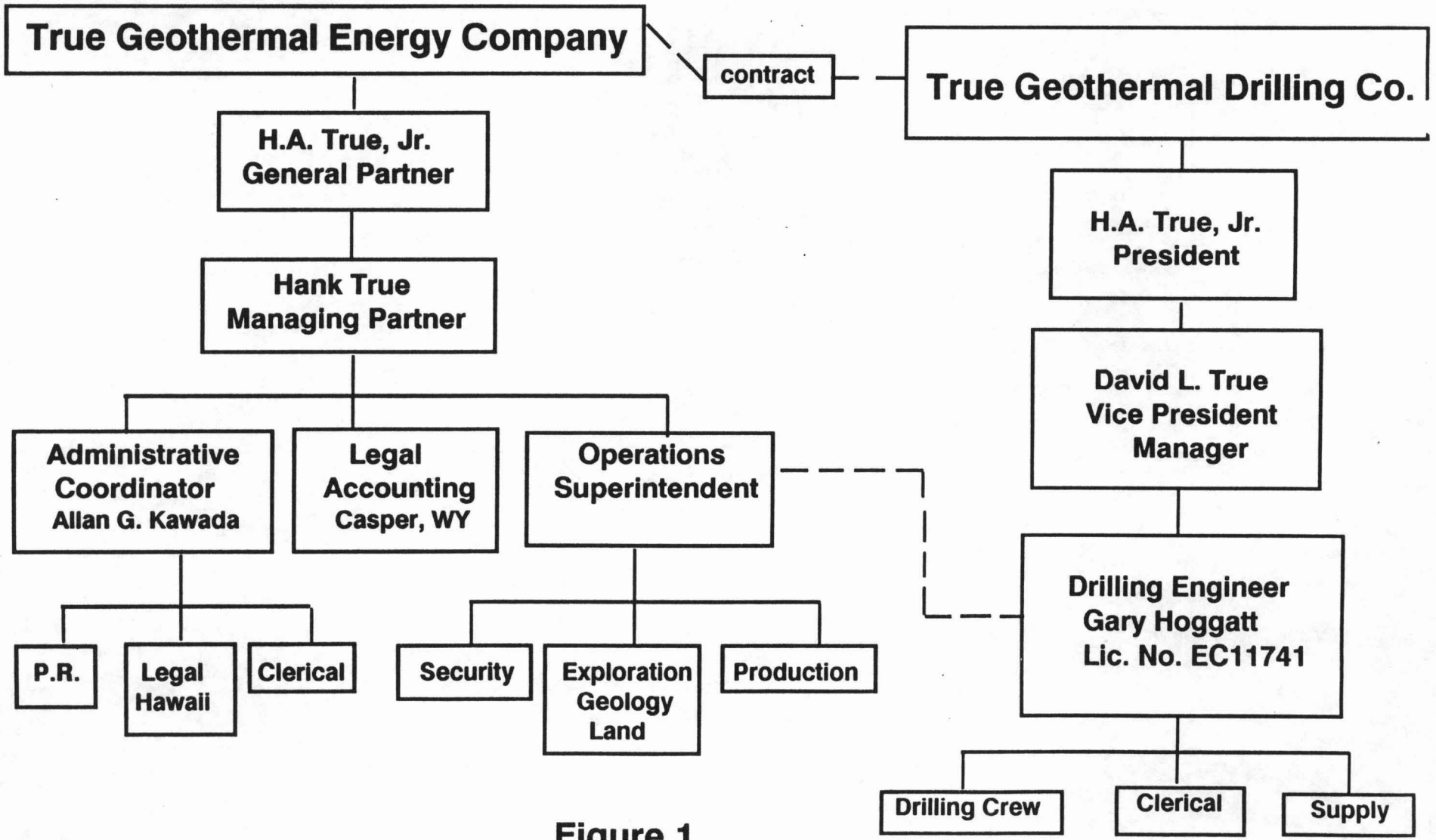


Figure 1

deep drilling into the area underlying the drilling site to depths between 8,000 feet and 14,000 feet and evaluate any discovered reservoir through flow testing and analyses of the resource to determine whether such energy sources can be economically produced to generate electricity. Discovery of a geothermal resource may occur in a zone beginning at a depth of about 3,000 feet below sea level. The optimum production zone will be determined following analysis of well drilling data and flow testing of the well. Following a successful exploration well, the subsequent exploration drilling will be conducted for the purpose of determining the general dimensions and extent of the reservoir and to prove the existence of sufficient resources to satisfy a known or potential future market.

5. Planned Well Drilling, Well Completion and Testing Programs

(See Attachment 1)

It should be noted that changes in the drilling programs described in the Attachment will occur due to varying project site and sub-surface conditions encountered during these operations, the characteristics of the resource and changing technology. The required changes can be expected to involve primarily casing dimensions, drilling depths and direction, and well-head assembly -- none of which will affect safety or reliability of drilling and production operations. All changes will be reported to DLNR as they occur. DLNR will be notified in advance of all critical well operations and tests.

6. Performance Bonds, Idemnity, Liability

As required by Paragraph 13-183-34 of DLNR Administrative Rules, Operator will file a bond with the Department of Land and Natural Resources in the amount of $10,000 made payable to the State conditioned upon faithful performance of all requirements of Chapter 182, Hawaii Revised Statutes, the Administrative Rules of DLNR (Chapter 183) and the State Geothermal Mining Lease No. R-5.

As required by Paragraph 13-183-65 of DLNR Administrative Rules, a blanket indemnity bond of no less than $250,000 will be filed with DLNR within 10 days of well permit approval for drilling of True/Mid-Pacific A1-1 to inure to and indemnify the state and landowner against all losses, charges, expenses and claims for damages or injuries caused or resulting from the drilling and operation of the wells. In addition, general liability insurance in the following amounts will be in force prior to commencement of operations (construction of the access road into the project site):

a. Comprehensive General Bodily Injury Liability - $300,000 each occurrence, $1,000,000 aggregate.
b. Comprehensive General Property Damage - $50,000 each occurrence, $100,000 aggregate.

Additional liability coverage for injury or damage to persons or property caused by explosion, collapse, and underground hazards is to be added prior to initiating drilling operations. The land owner (Campbell Estate), the State of Hawaii, Hawaii State Board of Land and Natural Resources, the Chairman of

the Board of Land and Natural Resources and the Department of Land and Natural Resources shall be named insurers.

Operator will also, prior to commencing operations, deposit with DLNR and Campbell Estate a bond naming the State of Hawaii and Campbell Estate as obligees in a penal sum of not less than One Hundred Percent (100%) of the cost of such construction in a form and with surety satisfactory to both parties guaranteeing the completion of such work free and clear of all mechanics' and materialmen liens.

Operator commits to perform the proposed operations in accordance with DLNR Administrative Rules (Chapter 183) and all other federal, state and county requirements.

TRUE GEOTHERMAL ENERGY COMPANY
(Operator for True/Mid-Pacific
Geothermal Venture)

_____
H. A. True, III, Partner

Attachment 1: Programs for Drilling.

PROGRAMS FOR DRILLING

A. Exploration Program

B. Drilling Operations

C. Well Testing and Reservoir Evaluation

D. Hydrogen Sulfide Monitoring and Abatement

Attachment 1
Application for
Permit to Drill

Programs For Drilling

A. Exploration Program

Inasmuch as the location of geothermal reservoirs must be determined by deep drilling and since the economic producibility of the resource from each discovered reservoir can only be determined by testing each successful well, the drilling sites selected, as shown in Figure 2, are tentative except for site A1. The exact location of other wells will depend upon previous drilling results and testing. The final surveyed location of each proposed well to be drilled will be reported in each application for permit to drill.

For planning purposes, five exploration/development (E/D) areas have been selected. Each area has three primary drilling sites planned (for a total of 15 sites) connected by access/service roads. Allowing for estimates of reserve wells and non-producible wells, a total of 35 individual wells within the 5 E/D areas may ultimately be required to produce 100 MW of electricity. The drilling sites will occupy up to 5 acres. If directional drilling in the Kilauea middle east rift zone is technically and economically feasible, up to 6 exploration/development wells may be drilled from one drilling site.

The first drilling site, True/Mid-Pacific A1, Figure 2, is planned near the eastern area of the proposed sub-zone, north of the rift zone center in E/D area "A". The general sequence of exploration drilling is as follows:

1) If the first exploration well in E/D areas "A" is successful, a second well will be drilled in this area to obtain indications of the northern boundary of the discovered reservoir. (A "successful"

well is one from which geothermal resources can be produced economically.) Regardless of the results of the second well, the next exploration well is planned to be drilled in E/D area "B", at or near one of the three planned sites.

2) If the first exploration well in E/D area "A" is not successful, the second well will be drilled at or near one of the three sites in E/D area "B" on the south side of the rift zone center near Pu'u Heiheiahulu.

3) If the first well in E/D area "B" is successful, another exploration well would be drilled at one of the other planned locations within E/D area "B". If the first well in this area is unsuccessful following a successful well in E/D area "A", the next well would be drilled at or near one of the three sites in E/D area "C", on the north side of the rift zone center.

4) If the first well is unsuccessful in E/D area "A" and E/D area "B", a decision would be made on whether to move to E/D area "E", in the western portion of the GRS near the more active section of the rift zone. If a well drilled at E/D area "E" is also unsuccessful, the project exploration strategy would be reevaluated.

5) If a successful well is drilled in E/D area "C", the next wells would be drilled in E/D area "D" and then "E".

6) After a resource discovery in any area, two or more additional exploration wells may be drilled in that area before proceeding to the next area if there is a local market demand for power which would require evidence of a resource sufficient to supply that demand.

Successful exploration wells would be shut-in after completion and testing if there is no immediate market for the resource.

B. Drilling Operations

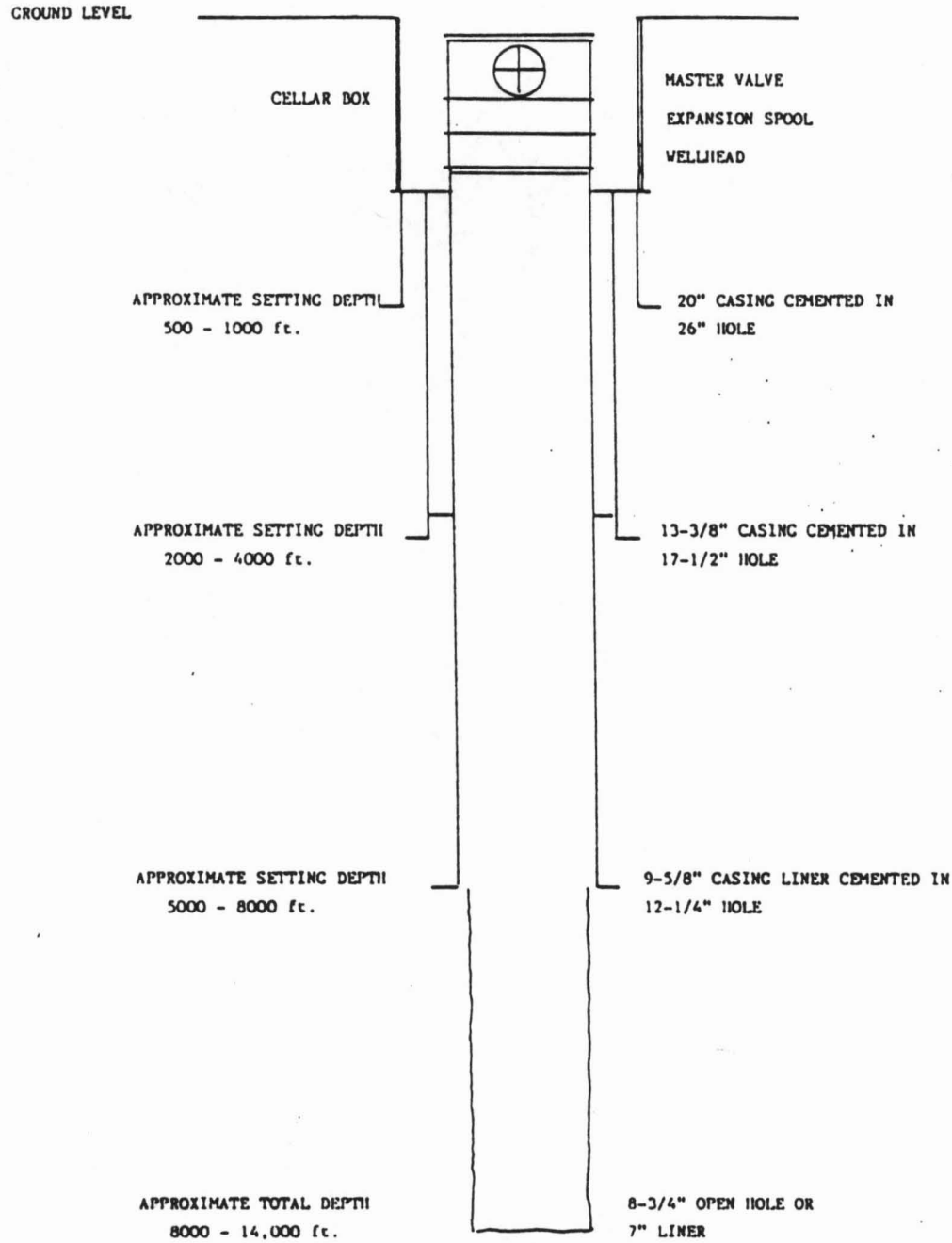
Figure 3 depicts the typical geothermal well profile showing the dimensions of the well bore and drill pipe or casing, and the depths to which specific sized casing is installed. Conductor pipe (normally 26"-28" diameter) is the first string of pipe installed to a depth of 100 to 150 ft. in a hole of 36" diameter followed by:

(1) surface casing (20" diameter to 500-1000 ft. depth) set in a hole of 26" diameter,

(2) Intermediate casing (13 3/8" diameter to 2000-4000 ft. depth) set in a hole of 17 1/2" diameter,

(3) Intermediate casing (9 5/8" diameter to 5000-7000 ft. depth) set in a hole of 12 1/4" diameter),

(4) Production (slotted) liner, if necessary (7" diameter to total depth set for commercial production) in a hole of 8 3/4" diameter.



Note: All depths expressed as true vertical.

REVISED	DATE

TSI ThermaSource Inc. 100 E Street • P.O. Box 1736 • Santa Rosa, California 95402 (707) 323 2900 • Telex 171743 • TWX 510 [illegible]

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FOR:
BY:
DATE:
SCALE:
DRAWING No.

Figure 3
TYPICAL WELL PROFILE
(True/Mid-Pacific Project)

The detailed sequence of events in the drilling program including the use of drilling mud, logging of drilling operations and analyses of core samples, well-head completion procedures and well bore directional programs are contained in Tab A to this attachment. The following is a general summary of these programs together with the well and reservoir testing procedures following the completion of discovery wells.

Depending on the subsurface geology, it is planned to drill with air from the surface to total depth using two low stage compressors with 1,200 CFM and one high stage compressor for pressure up to 400 psi providing the formations drilled are compatible. Air drilling is most successful in hard rock where there is no influx of formation waters. When air drilling is not possible, mud drilling will be conducted using the optimum mud weights and viscosity to remove the cuttings from the formations drilled. Under normal drilling conditions, approximately 2,000 barrels of water per day will be required. However, most of the water will be recycled. A rain catchment system with a capacity of 900,000 gallons will be constructed as a supplemental source to meet total project water requirements.

All casings will be joined and cemented to assure the integrity of the well bore from surface to the producing interval. The objective in cementing the casing is to completely seal the annular space between the wellbore and outside of the casing to resist landsliding and groundwater movement and to anchor the casing sections to the ground. The cement sheath will protect the casing against possible corrosion by thermal brines and gases, prevent uncontrolled flow of thermal water and steam outside the casing, and minimize

expansion. The casing will be cemented using API Class G or equivalent cement from the bottom of casing to the surface in accordance with industry standards.

Each well will have a casing head installed on the surface casing. A master gate valve will be installed on the casing head which will be left on the well. In addition, a hydraulically operated master gate valve with annular preventer (a blow-out preventer) will be installed as a component of the well head assembly. When air drilling is being conducted, a rotating head assembly will be installed for positive control.

The following standard safety devices will be used to protect against a blowout from the well:

1 Double Gate preventer with CSO rams plus 4-1/2-inch drill pipe rams, 12-inch 900 series.

1 Annular Preventer 12-inch 900 series.

1 Rotating Head when air drilling.

A blowout prevention system is individually designed for each cemented casing string. Figure 4 shows a typical blowout preventer system designed for high pressure wells.

While drilling, all operations data will be recorded and maintained at the drill site. All geologic information will be logged by a well site geologist. Summary reports will be prepared upon completion of each well, as well as the standard well completion reports.

In the event it becomes necessary to abandon a well, the operator will analyze data from the logs to determine what geologic formations are required to be covered by cement. The plugging will be performed through open ended drill pipe using API Class G or equivalent cement in accordance with industry standards. After the downhole plugging is performed, a cement plug will be placed in the top of the surface casing, the casing is cut off and the area backfilled and restored.

C. Well Testing and Reservoir Evaluation

After each well is completed, it will be vented to the atmosphere for four to eight hours to clear the well bore followed by an initial flow test by accepted industry methodology to get an approximation of its electric power production potential. If it is judged to be a possible commercial producer, extended flow testing will be conducted to acquire a full suite of data on the physical and chemical characteristics of the reservoir fluids using the flash steam separator, skid-mounted flow metering and temperature measurement equipment for steam and brine, noncondensable gas sampling equipment, and chemical injection and mixing equipment for abatement of H_2S.

Unabated open venting is required after a successful well is completed in order to clear the well bore and the area surrounding the hole of debris from drilling and small rocks that would initially be forced up the well bore due to the high pressure flow of the resources through the open end of the well bore. The timing of unabated open venting can, generally, be selected so that the restrictive hours and days (and favorable meteorological conditions) can be observed.

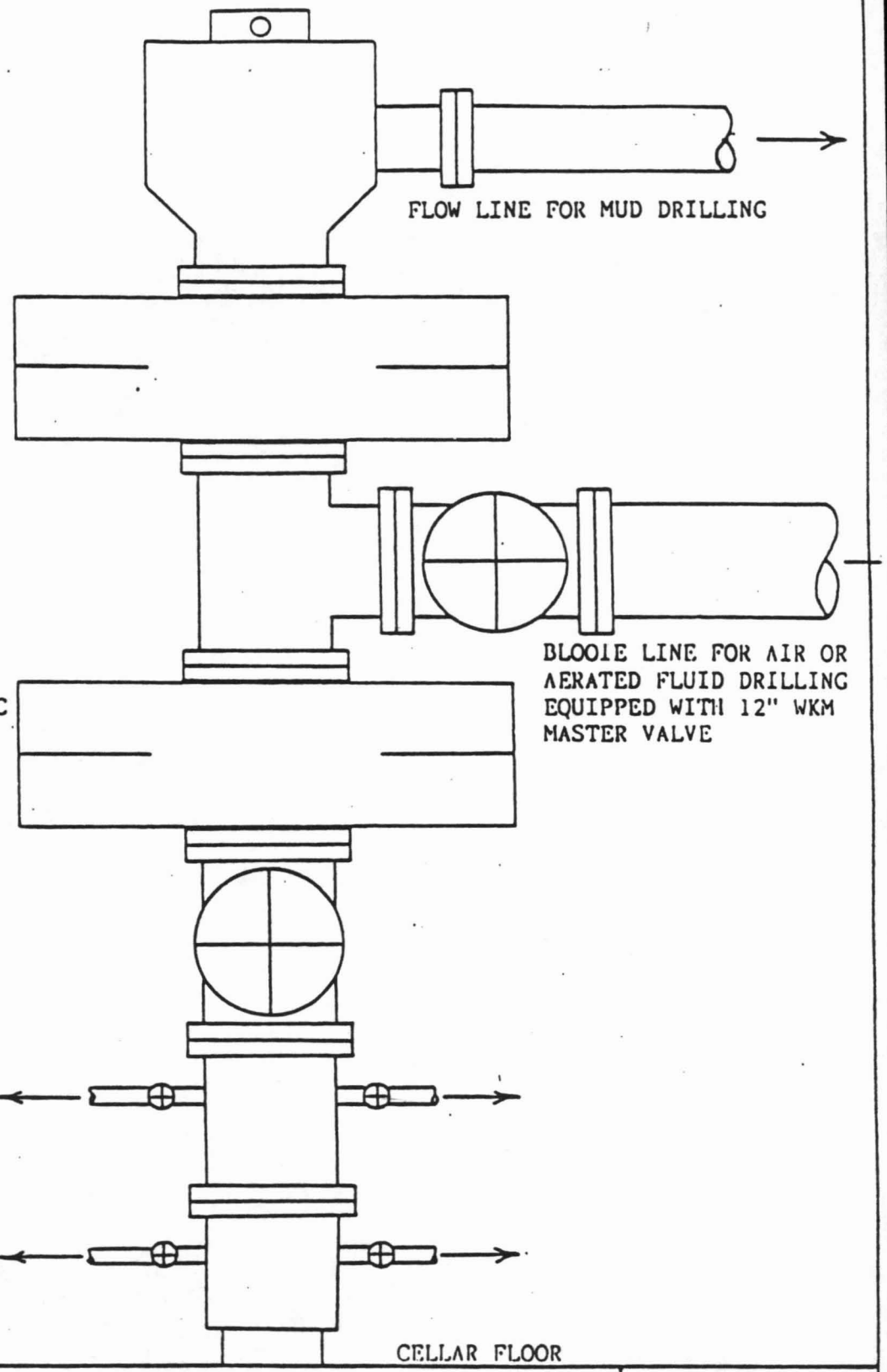
Due to the need to flow test each successful geothermal well in a normal, open-flow production mode in order to evaluate the reservoir, the characteristics of the resource, and the integrity of the well bore, it would not be possible to limit such testing to the 9-hours of abated venting specified in paragraph 6.(a) of the Decision & Order excluding weekends and state holidays and only under favorable meteorological conditions. These industry standard flow tests are continuous and can require 30 days or more to obtain reliable data. There is no known feasible alternative to flow testing of geothermal wells. Such tests are conducted with H_2S and noise abatement systems in operation. Also, the periodic shutting down or making significant changes in flow rates of a geothermal well can result in thermal shocks and damage to the well bore casing and cementing.

In view of the foregoing, DLNR was requestod to modify the restrictions imposed in the D & O since no suitable alternative is available. During flow testing, noise and H_2S will be abated to comply with prescribed standards; thus, abated venting would be permissible under terms of the D and O and existing regulations.

Testing of the wells will follow a procedure similar to the most recent test of the HGP-A well in Puna in which both noise and environmental pollution abatement was accomplished by use of a "sparging pit" and the injection of caustic soda to limit emissions of hydrogen sulfide gas.

The following criteria affect the economic potential of a reservoir to support a power generation operation at full capacity for 25-30 years:

TOTAL HEIGHT OF STACK: 298.5 INCHES = 87 FT.



TSI ThermaSource Inc.
P.O. Box 1236 • Santa Rosa, California 95402 • (707) 523-2960

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BY:	LEC
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SCALE:	N/A
DRAWING No.	

TRUE MID-PACIFIC/GEOTHERMAL PROJECT
BLOW OUT PREVENTER STACK FOR 13-3/8" CASING
FIGURE 4

Depth and subsurface structure.

Temperature of the fluid.

Downhole enthalpy.

Flow rate of each well.

Chemistry of the geothermal fluid.

Reservoir and production zone dimensions (reserves).

Reinjection potential.

Geothermal fluid produced during the production tests will flow to the well site sparging pit or the sump as appropriate. The project's environmental specialists will evaluate the reservoir fluids from each well and will consult with the appropriate regulatory agency to determine whether the fluid can be percolated into the ground or whether pond liners will be required. Due to the highly porous nature of the near surface formations, fluids should percolate readily into the ground. The chemistry of the well fluids are expected to be relatively benign, if similar to the HGP-A well, and should have no adverse impact on the basal water table at sea level due to the relatively low volume of fluid expected to flow from the well. Moreover, the basal water table within the rift zone is expected to contain natural geothermal effluents. Prior to injecting any geothermal effluent, the quality of water in the injection zone will be analyzed to verify that the basal water is not potable. During the production test, engineers will monitor the production rates, steam water ratio, hydrogen sulfide content, salinity, fluid chemistry, and noncondensable gas content. All of these items are necessary

to design an appropriate power plant and to devise an appropriate abatement system for protecting air quality, and the surface and subsurface environments.

When a potential reservoir has been encountered, interference tests will be run to establish intercommunication within the reservoir and provide the necessary engineering data to assess the volume of the geothermal fluid reserves, the available heat, and the estimated productive life of the reservoir. A geothermal reservoir engineer will be engaged to independently assess the geothermal energy potential of a discovered reservoir.

D. Hydrogen Sulfide (H_2S) Monitoring and Abatement During Drilling and Testing

Hydrogen sulfide, a colorless, acidic gas is toxic to humans and may be corrosive to metals in the presence of water. Drilling for geothermal resources in a hydrogen sulfide environment can be hazardous at and in the immediate vicinity of the drill site unless adequate safety precautions are taken.

The sense of smell cannot be relied upon to indicate either the presence or the concentration of H_2S gas. At lower concentrations, the odor of rotten eggs can be detected. At higher concentrations, (at 100ppm or above) the sense of smell is impaired in two to fifteen minutes. Direct exposure to concentrations in the range of 600ppm to 1500ppmv in the absence of any mixing or dispersion in the atmosphere could cause collapse, unconsciousness and death. The Occupational Safety and Health Administration (OSHA) permissible

exposure limit for an employee in an 8-hour work period is 10ppm with an excursion limit of 15ppm for 15 minutes during the 8-hour period. The proposed standard for H_2S exposure limit for the general public is a maximum ground level concentration of 0.1ppmv for 1 hour.

Safety measures to minimize the potential hazards to personnel from exposure to toxic levels of H_2S at or in the immediate vicinity of the drill site and emergency measures for accidents causing exposure to excessive levels of H_2S are discussed in Appendix A, Management Plan, and Appendix F, Emergency Plan.

From an environmental perspective, air quality regulations limit the amount of H_2S emissions during drilling operations to 8.5 lbs/hr. H_2S is expected to be present in the geothermal resource as a non-condensable gas in concentration levels between 1,000ppm and 1,300ppm.

H_2S monitoring equipment, including alarm systems, will be placed at the drilling rig (rig floor and well-head cellar) and at various locations within the drilling site and along the access road at the entrance to the drilling site to detect the presence of H_2S from any natural venting in the rift zone and due to emissions from geothermal resources brought to the surface during or as a result of drilling operations. Warning signs as to the potential presence of high concentrations of H_2S and safety precautions will be posted at the entrance to the project site and at the drill site.

Hydrogen sulfide concentrations in the steam flow through the well bore will be monitored continuously during air drilling operations by on-site well

loggers using an interference free H_2S detector, with periodic back-up wet chemical testing. Continuous monitoring and recording of the H_2S concentration in the blooie line (steel pipe leading from the well head to the atmospheric separator) is conducted using an electro chemical sensor. A wet chemical test system will be used to verify the continuous readings of the sensor. The data recorded will alert personnel when H_2S concentration levels in the steam flow require mass emission rate calculations to determine the need to activate and operate the H_2S abatement system. The injection of sodium hydroxide (NaOH) into the blooie line steam flow in proper proportions and amounts will enable the logger to maintain emission rates at or below the H_2S emission limit of 8.5 lbs/hr. A sodium hydroxide treatment mole ratio of 4 to 1 ($NaOH/H_2S$) will be used initially. The optimum chemical addition ratios will be determined during abatement operations and adjusted as necessary.

During drilling, residual H_2S from the steam flow following abatement will be released to the atmosphere through the atmospheric separator. Confirmation of the concentration levels of H_2S being emitted to the atmosphere will be determined from periodic analysis of samples of the steam taken from a port near the top of the separator. The abatement process is completed in the 2 to 3 seconds the steam flows from the well head through the blooie line to the outlet of the atmospheric separator. The desired level of abatement is achieved by adjusting the ratio of NaOH and H_2S.

Permanent records will be maintained on concentration levels of H_2S measured upstream of the abatement chemical injection port in the blooie line and in

the separator after chemicals have been injected. The H_2S emission rate can be calculated by multiplying the steam flow rate (lbs/hour) times the H_2S concentration in the steam in parts per million (ppm). Recorded data will show the following:

(1) Upstream of injection ports, the concentration of H_2S in ppm (volume) and ppm (weight)

(2) H_2S concentrations in lbs/hr from the separator after applying abatement chemicals

(3) Injection rates of NaOH

(4) Amount and type of chemicals on site

(5) Results of wet chemical tests

Emissions of particulates from air drilling will be controlled by water injection into the blooie line.

When drilling with mud, H_2S emissions are not expected to be detectable since the mud will prevent discharge of pollutants from the well bore.

Detailed Descriptions of Proposed Programs for Drilling, Casing, Cementing, Well Completion and Testing

Tab A to Attachment 1

Application For

Permit to Drill

TABLE OF CONTENTS

3. BLOW OUT PREVENTERS AND SPECIAL CONSIDERATIONS

18. BOP Stack for 26" Casing, Drawing 007
19. BOP Stack for 20" Casing, Drawing 008
20. BOP Stack for 13-3/8" Casing, Drawing 009
21. BOP Stack for 9-5/8" Casing with Expansion Spool, Drawing 010
22. Special Considerations
23. Tangential Muffler
24. Muffler and Dust Separator

4. WELL TESTING

25. Well Testing
26. Short Term Flow Test System Schematic, Figure 1

1. Drilling Program

Geothermal Drilling Program

Prepared by: Therma Source, Inc., Santa Rosa, CA
Geothermal Drilling & Reservoir Consultants

Operator: True Geothermal Energy Co., Casper, WY

Well Data

1) Location: Kilauea Middle East Rift Zone (KMERZ)
Puna District, Hawaii County, Hawaii
Campbell Estate Property
TMK 1-2-10:3

2) Elevation Above Sea Level - 1,500'

3) Proposed Verticle Depth - 8,000' to 14,000'

4) Estimated Drilling Time - 55 days

5) Estimated Total Time (Rig up to completion of drilling) - 70 days

Sequence of Operations

1. Construct drilling location with 8' x 8' x 4' cellar. Install 40' culvert to serve as conductor. Cement 40" culvert 4 to 5' above cellar floor. Cement floor of cellar and install drain to sump.

2. Rig up rotary drilling rig over center of culvert. Use culvert as a pitcher nipple and flowline.

3. Spud 36" hole and drill to 100'$^{\pm}$. Use air hammer if available.

4. Run 28" conductor pipe to total depth. Cement shoe with stab-in assembly through drill pipe. Install cement baskets on 28" casing. See attached 28" Casing Running and Cementing Program for details.

5. Install 28" blow out preventer on conductor as in attached Drawing 007. Test BOP to 100 psi for 15 minutes.

6. Drill out 28" conductor with 26" bit. Use air hammer. Drill 26" hole with mud or air to 500' - 1,000'. Take directional survey every 200' to maintain as straight a hole as possible. Collect and log cuttings samples every 10 feet.

7. If return circulation has been present during drilling, attempt to fill hole with water for logging. Log surface hole as indicated by geologist.

8. Run 20" surface casing to total depth. Cement 20" casing as described in attached 20" Casing Ruinning and Cementing Program. See Drawing 002 for details.

9. Install blow out preventers as in attached Drawing 008. Test preventers to 750 psi for 15 minutes.

10. Drill out 20" casing with 17½" bit. Attempt to drill with mud. If unsuccessful, drill with air to 2,000-2,500'±, 200' below fluid level. Take directional survey every 200'±. Maintain as straight a hole as possible. Maximum deviation to be 5°. Maximum rate of change to be 1½° per 100'.

11. Attempt to fill hole for logging. Log as indicated by geologist. Run multi-shot on conditioning trip before casing.

12. Run 13-3/8" casing as a liner to total depth. (If 20" casing is run only to 600'±, run 13-3/8" as a full string w/D.V.) Hang 13-3/8" 200'± up inside 20" casing. Cement 13-3/8" liner in one stage. Test and squeeze lap if necessary. Clean out to top of liner and run 13-3/8" tie-back string. Cement tie-back over entire interval. See attached 13-3/8" Liner and Tie-Back Running and Cementing Procedure for details and Drawings 003 and 004.

13. Install blow out preventer system as in attached Drawing 009. Test preventers to 1500 psi for 15 minutes.

14. Drill out cement from bottom of tie-back. Retest casing to 1500 psi.

15. Condition fluid in hole to mud. Drill out all cement from 13-3/8" casing.

16. Drill ahead with 12¼" bit to reservoir temperature, approximately 5,000-6,000'. Take directional survey every 200'. Maintain as straight a hole as possible. Maximum deviastion to be 8°. Maximum rate of change to be 1½° per 100'.

17. Run logs as indicated by geologist. Run multi-shot survey on condition trip before casing.

18. Run 9-5/8" casing as a liner to total depth. Hang 9-5/8" 200' - up inside 13-3/8" casing. Cement 9-5/8" liner in one or two stages as indicated from circulating conditions. Test and squeeze lap as necessary. Clean out to top of liner and run 9-5/8" tie-back string. Wait on 9-5/8" tie-back if 13-3/8" was run in an expansion spool. Cement tie-back over entire interval. See attached 9-5/8" Liner and Tie-Back Running and Cementing Program for details, and Drawings 005 and 006.

19. Install 9-5/8" expansion spool and blow out preventers as in attached Drawing 010. Test preventers to 1500 psi for 15 minutes.

20. Drill out cement from bottom of tie-back. Retest casing to 1500 psi.

21. Drill out all cement with mud. Convert system to water.

22. Blow out water with air and drill ahead with 8-3/4" bit to total depth or commercial production.

23. Test well on short term (8 hours). Shut well in and run in hole with bit to check for fill.

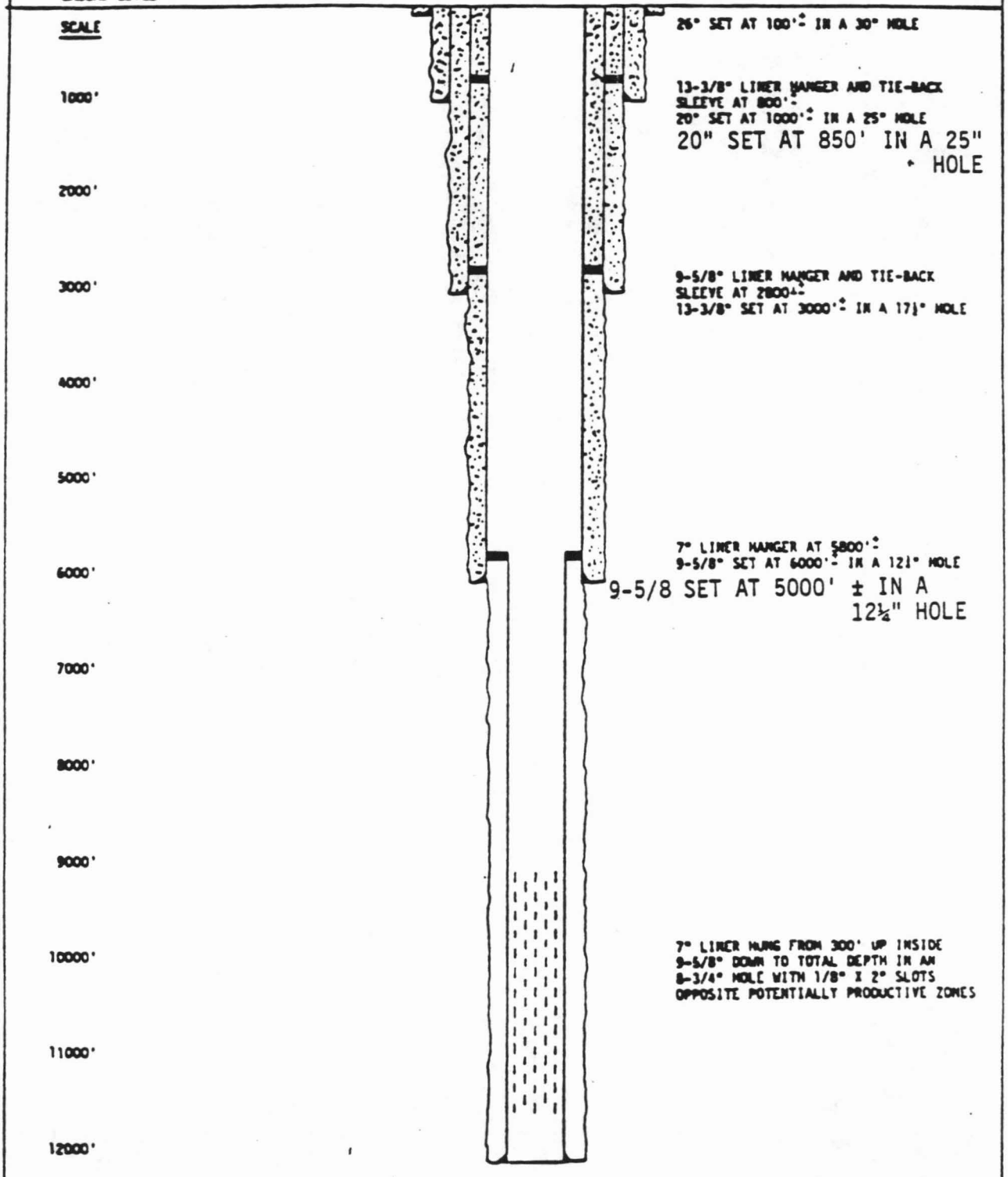
24. Run 7" slotted liner if indicated from bit run. See Drawing 001.

25. Retest well on short term (8 hours).

26. Run longs, pressure and temperature surveys.

27. Run in hole and pull out, laying down drill pipe. Release rig.

28. Perform long term test with mufflers and separators.



REVISED	DATE

TSI

WELL COMPLETION DIAGRAM
TRUE GEOTHERMAL

DRAWN	
FOR:	TRUE
BY:	LEC
DATE:	8/15/87
SCALE:	1"=1000' Vert.
DRAWING No.	001

ThermaSource Inc.
PO Box 1236 • Santa Rosa, CA 95402

MUD — MUD, LOGGING, WELLHEAD & DIRECTIONAL PROGRAMS

WELL: True No. 1

DEPTH INTERVAL	MUD TYPE	WEIGHT	API FLUID LOSS	YIELD POINT	PH	
- 100'	Gel and Water	65#/ft.^{3}	---	15	9.0	
00 - 1000'	Gel and Water or Air*	70#/ft.^{3}	10 cc	15	9.0	
1000' - 3000'	Gel and Water or Air*	70#/ft.^{3}	10 cc	15	10.0	
3000 - 6000'	Gel and Water or Air*	70#/ft.^{3}	3.2 cc	15	10.0	
5000 - T.D.	Water or Air*	65#/ft.^{3}	or 3000 cfm			

REMARKS
* If unable to maintain circulation due to lost circulation, first attempt to aerate system, then attempt to drill with air with rotary bit or air hammer (see attached). If misting is required, it may be necessary to increase air volume 30%. Misting mix should be fresh water mixed with 2-6 gal/10 bbls of Magcobar Foamer. Maintain a solution pH above 10.0 to inhibit corrosion. Use unisteam as outlined in special considerations.

LOGGING

DEPTH INTERVAL	LOG TYPES	LOG SCALES
100 - 1000'	Temperature log & logs as directed	1" and 5" = 100'
1000 - 3000'	" " " "	" "
3000 - 6000'	" " " "	" "
5000 - T.D.	" " " "	" "
- T.D.	Samples every 10'	

REMARKS
All logs to be determined by geologist.

WELLHEAD

API NOMINAL SIZE	WORKING PRESSURE PSI	TYPE	MAKE
26"	100 psi	Single ram type or hydril	
20" x 20"	750 psi	*WKM-20" S.O.W.x21" 2000	WELLHEAD
13-3/8" x 12"	1500 psi	21"x 2000 x 12" 900 API with 12¼" bore ~~and 2-3 2000 psi outlets.~~ **	WKM
12" x 10"	1500 psi	12" 900 x 10" 900 expansion spool with	WKM
10" x 10"	1500 psi	10" bore and 2-3 200 psi outlets. ~~10" 900 Pow-R-Seal valve~~	WKM

REMARKS
20" 600 API x 20" 600 API with 2 outlets weld-on flange will due.
*OPTIONAL

DIRECTIONAL OR STRAIGHT-HOLE

Drill hole as straight as possible, taking directional shots every 200'± from 0-6000' and on dull bits after 6000'. 0-3000' maximimum deviation to be 5°, maximum rate of change to be ½° per 100'. 3000-6000' maximum deviation to be 8°, maximum rate of change to be 1½° per 100'. 6000'-T.D. monitor without control.

2. Casing & Cementing

ThermaSource Inc.
Box 1236 • Santa Rosa, CA 95402

CASING, CEMENTING AND BOP PROGRAMS

CASING PROGRAM | SIZE: 26" | DEPTH: 100'± | Conductor | WELL: True No. 1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS: TOP BURST	BOT. BURST	COLL.	TENSION
0 - 100'±	3/8" WALL.		PLAIN END				

DESIGN CONDITIONS

RFACE BURST PRESSURE -	PSI	OUTSIDE MUD WT. (COLLAPSE) -	PPG
INSIDE MUD WEIGHT (BURST) -	PPG	INSIDE MUD WT. (COLLAPSE) -	PPG
TSIDE MUD WEIGHT (BURST) -	PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -	PPG
AC. GRAD. AT SHCE (BURST) -	PPG	BIAXIAL LOAD: COLL. ☐ BURST ☐	BOUYANCY: YES ☐ NO ☐

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

250 cu. ft. (218 sacks) of class G cement blended with 3% $CaCl_2$.

		DESIRED TOP: Surface	EXCESS: 100%
SLURRY VOL. - CU FT / (SLURRY NO.)	250		
SLURRY YIELD - CUBIC FEET/SACK	1.15		
SLURRY DENSITY - [redacted] #/cu. ft.	118		
THICKENING TIME - DEPTH SCH/HRS. MIN.	4 hours ±		
COMPRESSIVE STRENGTH - PSI/HOURS	1870 psi @ 100°F in 8 hours.	3885 psi @ 100°F in 24 hours.	

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Weld-on float collar located 10' from bottom.
2. All joints should be welded.
3. Set casing on bottom. Put cement ports in pipe, 1', 2', and 3' up.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. No centralizers.
2. Run one cement basket 10' up from bottom.
3. Run one cement basket 50' up from bottom and one 15' below surface.

PRE FLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

1. Stab into float collar with drill pipe.
2. Attempt to pump water around.
3. Pump 200 cu. ft. $CaCl_2$ water, 100 cu. ft. fresh water, 200 cu. ft. Flo-Chek ahead of cement followed by Geo-gel then 100 cu. ft. cement.

PRESSURE TESTING AND LANDING

1. Fill annulus from surface with ready mix concert until cement comes up to bottom of cellar.
2. Wait on cement six hours before landing and cutting off casing for blow out preventers.

BOP PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI: RAM TYPE	ANNULAR TYPE	ROTATING HEAD
	1000 psi	25"	See Drawing 007	---	100 psi	----

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CASING, CEMENTING AND BOP PROGRAM

CASING PROGRAM | SIZE: 20" | DEPTH: 500-1,000' | Surface | WELL: True No. 1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS: TOP BURST	BOT. BURST	COLL.	TENSION
- 1000'±	106ppf	K-55	Butress	3.31	9.21	1.64	9.99

DESIGN CONDITIONS

SURFACE BURST PRESSURE	- 750	PSI	OUTSIDE MUD WT. (COLLAPSE) -	9.0	PPG
INSIDE MUD WEIGHT (BURST)	- 13.0	PPG	INSIDE MUD WT. (COLLAPSE) -	0	PPG
OUTSIDE MUD WEIGHT (BURST)	- 9.0	PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -		PPG
FRAC. GRAD. AT SHOE (BURST)	- 14.0	PPG	BIAXIAL LOAD: COLL. [X] BURST [X]	BOUYANCY: YES [ ] NO [X]	

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

2152 cu. ft. (624 sacks) class G cement blended with 50#/sack of spherelite cement, 40% silica flour, 5% hydrated lime, 4% gel, 1% CFR-2 and 0.5% Halad-22A, tailed with 300 cu. ft. (261 sacks) class G cement blended with 3% $CaCl_2$.

DESIRED TOP: Surface | EXCESS: 100%

SLURRY VOL. - CU FT / (SLURRY NO.)	2152	300		
SLURRY YIELD - CUBIC FEET/SACK	3.45	1.15		
SLURRY DENSITY - [redacted] #/cu. ft.	82	118		
THICKENING TIME - DEPTH SCH/HRS. MIN.	4 hours	4 hours		
COMPRESSIVE STRENGTH - PSI/HOURS				

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Stab in type float collar loacted 40' up from bottom. Guide shoe on bottom.
2. Weld bottom of collars on bottom 4 joints.
3. Clean and Bakerloc threads on bottom 4 joints.
4. Tac-weld top of collars on last 2 joints.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. Run centralizer in middle of bottom two joints, then one every other tool joint on entire string except top 100'.
2. Put centralizer cement baskets in middle of bottom 2 joints, one at 500' down, one at 120', and 90' down from surface.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

1. Stab into float collar with drill pipe. Attempt to circulate with water.
2. Pump 200 cu. ft. $CaCl_2$ water followed by 100 cu. ft. fresh water, 200 cu. ft. Flo-Chek, 200 cu. ft. Geo-gel, then cement slurries.
3. See attached detail.

PRESSURE TESTING AND LANDING

1. Use 1" pipe in annulus of 20" and 26" to bring cement back to surface if necessary.
2. Wait on cement six hours.

BOP PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI: RAM TYPE	ANNULAR TYPE	ROTATING HEAD
	1000 psi	20"	See Drawing 008	750 psi	750 psi	----

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20" CASING CEMENTING PROCEDURE

1. Run 20" casing into hole with stab-in type cementing float 80' above guide shoe on bottom.

2. Place a cement basket type centralizer in the middle of the bottom two joints. Place one 500' down and one just inside and one just outside the bottom of the 26" casing.

3. Run in hole with drill pipe and stab into float. Pump enough water to fill drill pipe and 20" x 25" annulus two times. If no circulation, proceed with cementing. See Drawing 002. Tie down casing prior to cementing.

4. Pump 200 cu. ft. $CaCl_2$ water and 100 cu. ft. fresh water, followed by 200 cu. ft. Halliburton Flo-Chek, 200 cu. ft. Geo-gel flush, then cement slurries for Stage 1.

5. If lead cements start coming out of annulus, immediately switch to tail slurry.

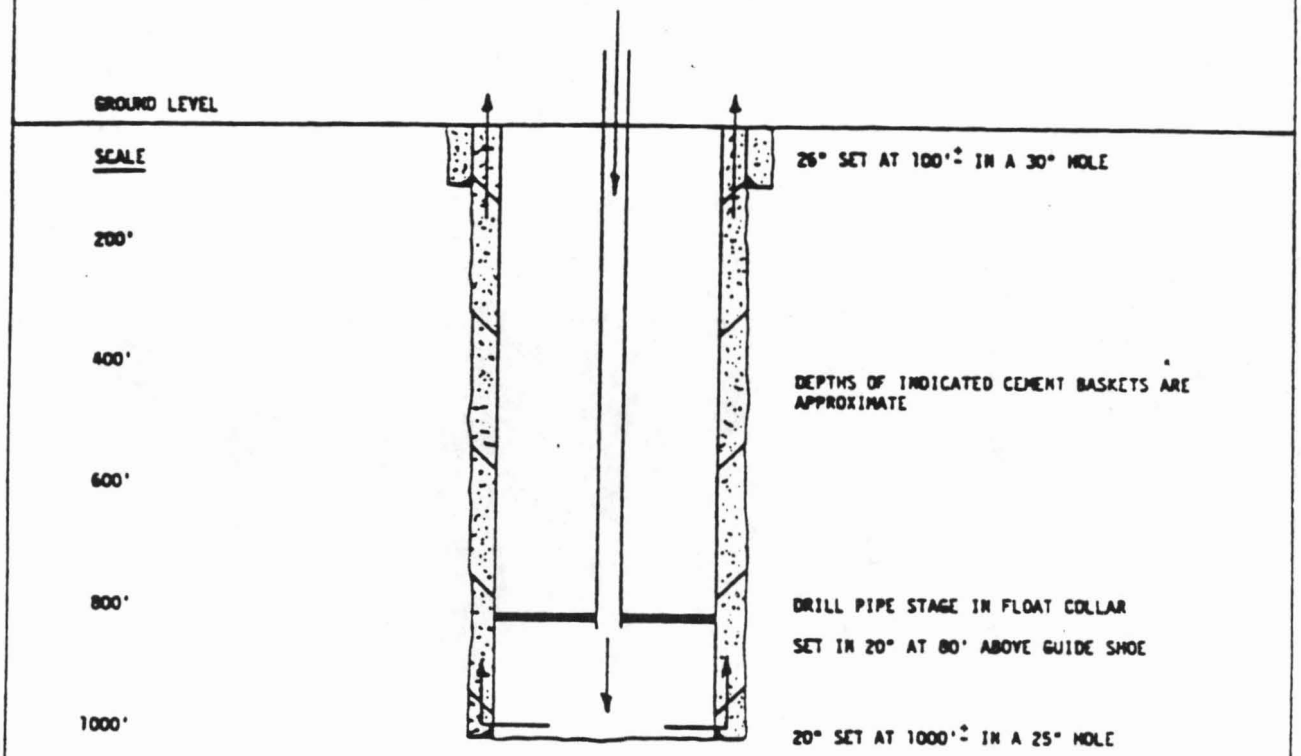
6. Pull out drill pipe. Pull up one joint and displace cement out drill pipe.

7. Pull drill pipe out of hole and wait on cement. If cement had come to surface up the annulus, check after six hours. Refill is necessary.

8. If cement had not come to surface during primary cement job, which is likely the case, run into 26" x 20" annulus with 1" tubing down to upper cement basket. Pump in enough cement to fill 10 linear feet of 26" x 20" annulus, approximately 15.7 cu. ft. Pull up and wait on cement.

9. Go down and feel for cement top. Repeat if necessary and then fill up 26" x 20" annulus to surface with class G cement blended with 40% silica flour and 0.5% CFR-2.

10. Wait on cement six hours and land 20" casing. Cut off 20" and 26" casing. Prepare to install wellhead assemblies.



REVISED	DATE

TSI Thermal Source Inc.

20" CASING AND CEMENTING PROGRAM

DRAWN FOR: TRUE
BY: LEC
DATE: 8/15/87
SCALE: 1"=200' Vert.
DRAWING No. 002

ThermaSource Inc.
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CASING, CEMENTING AND BOP PROGRAMS

CASING PROGRAM — SIZE: 13-3/8" — DEPTH: 800' ± — Tie-Back — WELL: True No. 1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS			
				TOP BURST	BOT. BURST	COLL.	TENSION
0 - 800' ±	54.5	K-55	Buttress	1.29*	1.54	3.04	9.99

*Calculated using fracture gradient with 13-3/8" liner shoe at 3000'

DESIGN CONDITIONS

SURFACE BURST PRESSURE	- 1500.	PSI	OUTSIDE MUD WT. (COLLAPSE) -	9.0	PPG
INSIDE MUD WEIGHT (BURST)	- 13.0	PPG	INSIDE MUD WT. (COLLAPSE) -	0	PPG
OUTSIDE MUD WEIGHT (BURST)	- 8.6	PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -		PPG
FRAC. GRAD. AT SHOE (BURST)	- 14.0	PPG	BIAXIAL LOAD: COLL. [X] BURST [X]	BOUYANCY: YES [ ] NO [X]	

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

1059.8 cu. ft. (654 sacks) class G cement blended with 40% silica flour and 0.5% CFR-2.

DESIRED TOP: Surface — EXCESS: 30%

SLURRY VOL. - CU FT / (SLURRY NO.)	1059.8			
SLURRY YIELD - CUBIC FEET/SACK	1.62			
SLURRY DENSITY - [redacted] #/ cu. ft.	116			
THICKENING TIME - DEPTH SCH/HRS. MIN.	2 - 3 hours			
COMPRESSIVE STRENGTH - PSI/HOURS	± 2323/8 hours			

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Run float collar 40' above tie-back sleeve on bottom.
2. Clean and Bakerloc threads on bottom 4 joints.
3. Tac-Weld top and bottom of collars on bottom 2 joints.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. Run centralizer in middle of bottom joint and one every other tool joint to surface except for top 100'.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

1. Circulate with fresh water.
2. Run top plug only.
3. See attached program for more detail.

PRESSURE TESTING AND LANDING

1. Wait on cement six hours before landing and cutting off 13-3/8" for wellhead.

BOP PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI		
				RAM TYPE	ANNULAR TYPE	ROTATING HEAD
	1500 psi	12-3/8"	See Drawing 009	1500psi	1500 psi	----

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CASING, CEMENTING AND BOP PROGRAMS

CASING PROGRAM — SIZE: 13-3/8" — DEPTH: 2,000-2,500' Liner — WELL: True No. 1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS: TOP BURST	BOT. BURST	COLL.	TENSION
000 - 2000'±	54.5	K-55	Buttress	1.58	2.19	1.16	4.33
2000' - 3000'	61.0	K-55	Buttress	2.47	3.67	1.10	9.99

DESIGN CONDITIONS

RFACE BURST PRESSURE	-	1500 PSI	OUTSIDE MUD WT. (COLLAPSE) -	9.0	PPG
INSIDE MUD WEIGHT (BURST)	-	13.0 PPG	INSIDE MUD WT. (COLLAPSE) -	0	PPG
TSIDE MUD WEIGHT (BURST)	-	8.6 PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -		PPG
HAC. GRAD. AT SHOE (BURST)	-	14.0 PPG	BIAXIAL LOAD: COLL. [X] BURST [X]	BOUYANCY: YES [ ] NO [X]	

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

2682.2 cu. ft. (778 sacks) class G cement blended with 50# per sack of cement of spherelite, 40% silica flour, 5% hydrated lime, 4% gel, 1% CFR-2, and 0.5% Halad-22A, tailed with 300 cu. ft. (185 sacks) of class G cement blended with 40% silica flour and 0.5% CFR-2.

DESIRED TOP: 800'± — EXCESS: 100%

SLURRY VOL. - CU FT / (SLURRY NO.)	2682.2	300		
RY YIELD - CUBIC FEET/SACK	3.45	1.62		
SLURRY DENSITY - [redacted] #/cu.ft.	82	116		
ICKENING TIME - DEPTH SCH/HRS. MIN.	4 hours	2 - 3 hours		
COMPRESSIVE STRENGTH - PSI/HOURS		±2323/8 hours		

RUNNING AND CEMENTING INSTRUCTIONS

E, COLLAR(S) AND JOINT STRENGTHENING
1. Run float collar 40' above float shoe.
2. Weld bottom of collars on bottom 4 joints.
3. Clean and Bakerloc threads on bottom 4 joints.
4. Tac-weld top of collars on last 2 joints.

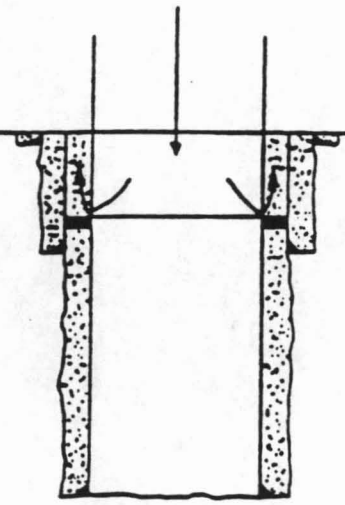
CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING
1. Hang liner 200' up inside 20" casing on drill pipe.
2. Run centralizer cement baskets in middle of bottom 2 joints and one 10' up inside 20" casing and one just below stage collar if a stage is indicated.
3. Run centralizers every other tool joint to bottom of 20" casing.

FLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.
1. Attempt to circulate with water.
2. Pump 200 cu.ft. $CaCl_2$ water and 100 cu.ft. water, followed by 200 cu.ft. Flo-Chek then 200 cu.ft. of Geo-gel, then cement slurries.
3. See attached program for more detail.

PRESSURE TESTING AND LANDING
1. Wait on cement 6 hours. Clean out cement from top of 13-3/8" liner. Test lap to 750 psi. Squeeze lap if necessary. Clean out and retest until a test is obtained.

PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI: RAM TYPE	ANNULAR TYPE	ROTATING HEAD



26" SET AT 100'± IN A 30" HOLE

13-3/8" TIE-BACK STRING STINGS INTO SLEEVE 4' TO 5' AT LINER TOP AT 800'±
20" SET AT 1000'± IN A 25" HOLE

13-3/8" LINER HUNG FROM 200'± UP INSIDE 20" DOWN TO T.D. 3000'± IN A 17½" HOLE

ARROWS INDICATE DIRECTION OF CEMENT FLOW

REVISED	DATE

TSI Thermal Source Inc. [illegible]

13-3/8" TIE-BACK RUNNING AND CEMENTING PROGRAM

DRAWN
FOR: TRUE
BY: LEC
DATE: 8/15/87
SCALE: 1"=1000' Vert
DRAWING No. CD1

ThermaSource Inc.
P.O. Box 1236 • Santa Rosa, CA 95402

13-3/8" LINER AND TIE-BACK
RUNNING AND CEMENTING PROCEDURE
(Run as a full string if 20" string was run shallow)

1. Drill to casing depth.
2. Attempt to fill hole with water and circulate.
3. Rig up loggers and run logs as indicated by geologist.
4. Run in hole with 17½" bit and monel drill collar. Attempt to condition hole for casing. Pull out and run multi-shot directional survey.
5. Pick up 13-3/8" liner. If circulation was never achieved, then a stage collar should be installed at approximately 2000'±. Install cement basket type centralizers in the middle of the bottom two joints and one just below stage collar. Install one cement basket type centralizer 20' below 20" casing shoe and one 20' up inside 20" casing shoe.
6. Run liner in hole and hang same 200' up inside of 20" casing with shoe just off bottom.
7. Attempt to circulate with two times total volume of fresh water. If unsuccessful, then proceed with cement job. See Drawing 003.
8. Pump 200 cu. ft. $CaCl_2$ water and 100 cu. ft. fresh water, followed by 200 cu. ft. Halliburton Flo-Chek, 200 cu. ft. Geo-gel flush, then cement slurries. for Stage 1.
9. Release plugs and repeat preflush for Stage 2 and close cementing ports if necessary.
10. Release hanger and pull out of hole with setting tool. Wait on cement for six hours.
11. Run inhole with 17½" bit and clean out excess cement, if any, from the top of the 13-3/8" liner.
12. Test lap to 750 psi. If unable to get a test, trip to lay down bit, run in open ended. Squeeze lap with class G cement blended with 40% silica flour and 0.5% CFR-2 using pipe rams.
13. Re-squeeze until a squeeze pressure is achieved. Fill hole with water.
14. Drill out excess cement with 17½" bit and retest lap to 750 psi.
15. If successful in testing lap, run in hole with 12¼" bit and 13-3/8" casing scraper to clean out tie-back sleeve.
16. Pick up 13-3/8" tie-back with float collar located 40' above tie-back stinger on bottom. See Drawing 004.
17. Run tie-back string in hole and land same in sleeve at hanger.

18. Circulate around with fresh water, then run cement slurry. Use top plug only.

19. Wait on cement six hours. If after six hours cement is not to surface level in 13-3/8" x 20" annulus, insert 1" tubing and bring it back to surface with cement.

20. Cut off 20" and 13-3/8" casing strings. Install wellhead and blow out preventers as in Drawing 009.

ThermaSource Inc.
P.O. Box 1236 • Santa Rosa, CA 95402

CASING, CEMENTING AND BOP PROGRAM

CASING PROGRAM — SIZE: 9-5/8" — DEPTH: 2800'± — Tie Back — WELL: True No. 1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS: TOP BURST	BOT. BURST	COLL.	TENSION
- 2800'	20	L-80	Buttress	2.53	2.35	1.40	4.85

(Hold on this string until after test)

DESIGN CONDITIONS

SURFACE BURST PRESSURE	- 1500	PSI	OUTSIDE MUD WT. (COLLAPSE) -	9.0	PPG
INSIDE MUD WEIGHT (BURST)	- 13.0	PPG	INSIDE MUD WT. (COLLAPSE) -	0	PPG
OUTSIDE MUD WEIGHT (BURST)	- 9.0	PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -		PPG
FRAC. GRAD. AT SHOE (BURST)	- 14.25	PPG	BIAXIAL LOAD: COLL. [X] BURST [X]	BOUYANCY: YES [ ] NO [X]	

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION AND NUMBER:
1140 cu. ft. (704 sacks) class G cement blended with 40% silica flour and 0.5% CFR-2.

	DESIRED TOP	EXCESS
	Surface	30%

SLURRY VOL. - CU FT / (SLURRY NO.)	1140			
SLURRY YIELD - CUBIC FEET/SACK	1.62			
SLURRY DENSITY - [redacted] #/cu. ft.	116			
THICKENING TIME - DEPTH SCH/HRS. MIN.	2 - 3 hours			
COMPRESSIVE STRENGTH - PSI/HOURS	±2323 psi/8 hours			

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING
1. Run float collar 40' above tie-back sleeve on bottom.
2. Clean and Bakerloc threads on bottom 4 joints.
3. Tac-weld top and bottom of collars on bottom 2 joints.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING
1. Run centralizers in middle of bottom joint and one every other tool joint to surface, except for top 100'.

REFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.
1. Circulate with fresh water.
2. Run top plug only.
3. See attached program for more detail.

PRESSURE TESTING AND LANDING
1. Wait on cement six hours before landing and cutting off 9-5/8" for expansion spool and blow out preventers.

PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI: RAM TYPE	ANNULAR TYPE	ROTATING HEAD
	1500 psi	8-3/4"	See Drawing 010	1500 psi	1500 psi	1000 psi

GROUND LEVEL

SCALE

1000'

2000'

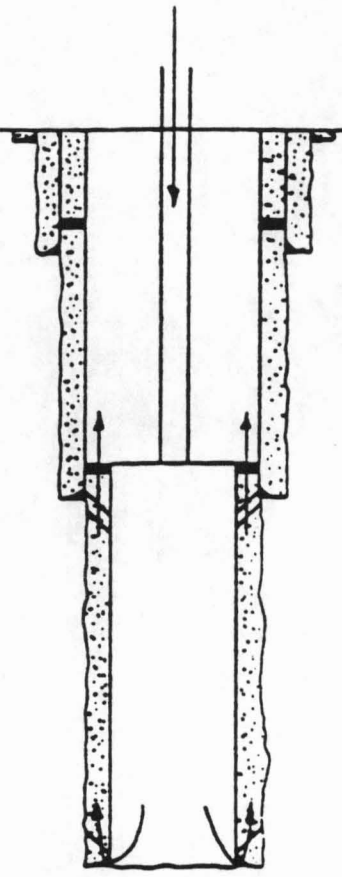
3000'

4000'

5000'

6000'

7000'



ARROWS INDICATE DIRECTION OF CEMENT FLOW

26" SET AT 100'± IN A 30" HOLE

13-3/8" TIE-BACK STRING SET AT LINER TOP AT 800'±
20" SET AT 1000'± IN A 25" HOLE

9-5/8" LINER HUNG WITH DRILL PIPE AT 2800'±

13-3/8" LINER HUNG FROM 200'± UP INSIDE 20" DOWN TO 3000'± IN A 17½" HOLE.

9-5/8" LINER HUNG FROM 200'± UP INSIDE 13-3/8" DOWN TO T.D. 6000' IN A 12¼" HOLE

REVISED	DATE

TSI Thermal Source Inc. 900 [illegible] Street • P.O. Box 1736 • Santa Rosa, California 95402 (707) 523-2900 • Telex 171748 • FAX 3[illegible]

9-5/8" LINER RUNNING AND CEMENTING PROGRAM

DRAWN FOR: TRUE
BY: LEC
DATE 8/15/87
SCALE 1"=1000' Vert.
DRAWING No. 005

P.O. Box 1236 • Santa Rosa, CA 95402

CASING, CEMENTING AND BOP PROGRAMS

SIZE 9-5/8" | DEPTH 6000'±

ner | WELL True No. 1

CASING PROGRAM

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS TOP BURST	BOT. BURST	COLL.	TENSION
2800 - 3300	36	K-55	LT&C or Buttress	2.56	2.54	1.16	3.88
3300 - 4500	40	K-55	LT&C or Buttress	2.82	2.74	1.16	5.19
4500 - 6000	40	N-80	LT&C or Buttress	3.95	3.52	1.10	9.99

DESIGN CONDITIONS

SURFACE BURST PRESSURE	-	1500 PSI	OUTSIDE MUD WT. (COLLAPSE) -	9.0	PPG
INSIDE MUD WEIGHT (BURST)	-	13.0 PPG	INSIDE MUD WT. (COLLAPSE) -	0	PPG
OUTSIDE MUD WEIGHT (BURST)	-	9.0 PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -		PPG
FRAC. GRAD. AT SHOE (BURST)	-	14.25 PPG	BIAXIAL LOAD: COLL. [X] BURST [X]	BOUYANCY: YES [ ] NO [X]	

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

1649 cu. ft. (478 sacks) class G cement blended with 50# per sack of cement of spherelite, 40% silica flour, 5% hydrated lime, 4% gel, 1% CFR-2 and 0.5% Halad-22A. Tailed with 300 cu. ft. (185 sacks) of class G cement blended with 40% silica flour and 0.5% CFR-2

DESIRED TOP 2800' | EXCESS 100%

SLURRY VOL. - CU FT / (SLURRY NO.)	1649	300		
SLURRY YIELD - CUBIC FEET/SACK	3.45	1.62		
SLURRY DENSITY - PPG	82	116		
THICKENING TIME - DEPTH SCH/HRS. MIN.	4 hours	2-3 hours		
COMPRESSIVE STRENGTH - PSI/HOURS				

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Run float collar 80'- above float shoe.
2. Weld bottom of collars on bottom 4 joints.
3. Clean and Bakerloc threads on bottom 4 joints.
4. Tac-weld top of collars on last 2 joints.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. Hang liner 200'- up inside 13-3/8" casing on drill pipe.
2. Run centralizer cement baskets in middle of bottom 2 joints and one 10' up inside 13-3/8" casing and one just below stage collar is a stage is indicated.
3. Run a centralizer every other tool joint to bottom of 13-3/8" casing.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

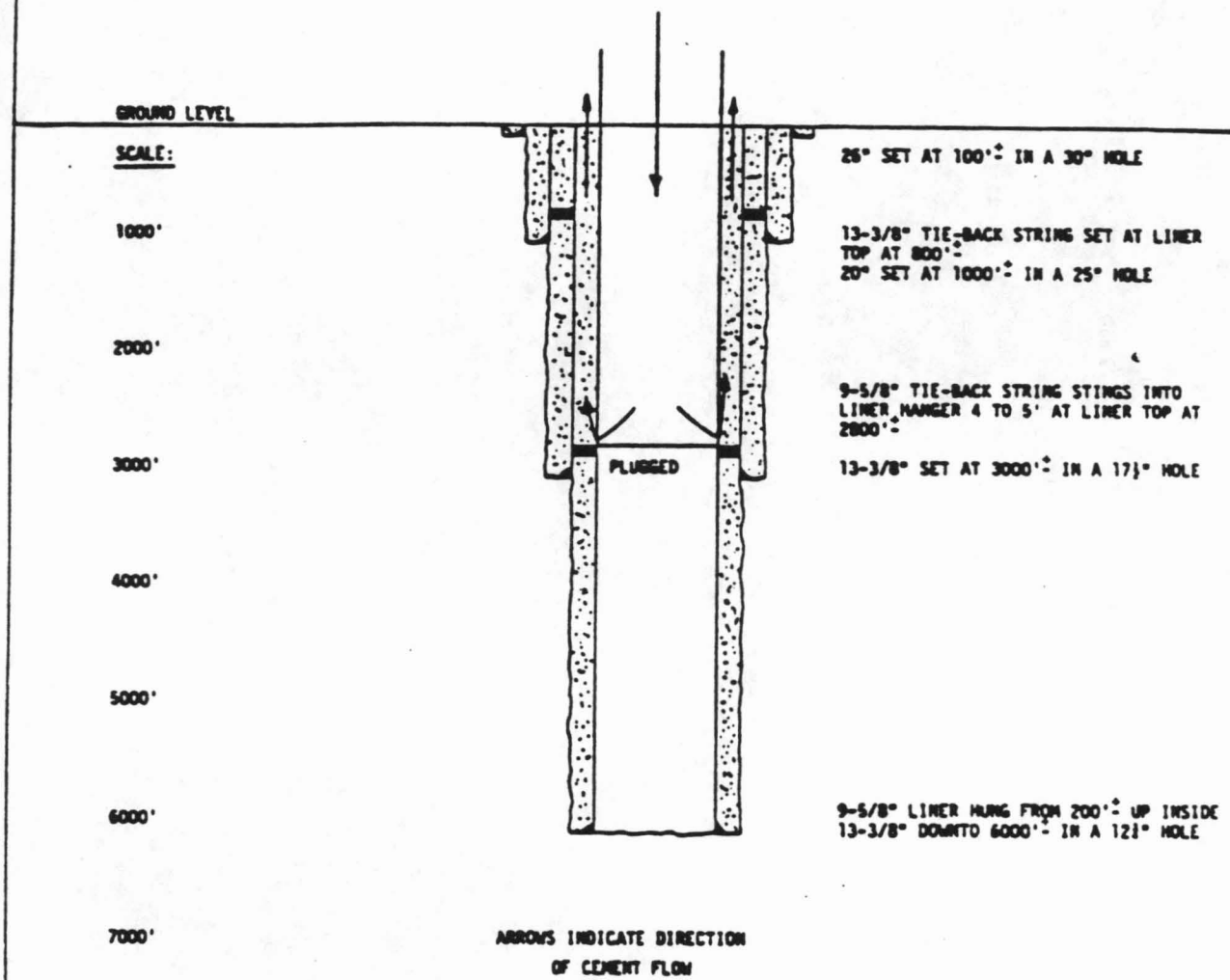
1. Attempt to circulate with water.
2. Pump 200 cu. ft. $CaCl_2$ water followed by 100 cu. ft. fresh water, then 200 cu. ft. Halliburton Flo-Chek, then 200 cu. ft. of Geo-gel then cement slurries.
3. See attached program for more detail.

PRESSURE TESTING AND LANDING

1. Wait on cement six hours. Clean out cement from top of 9-5/8" liner. Test lap to 1000 psi. Squeeze lap if necessary. Clean out and retest until a test is obtained.

PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI RAM TYPE	ANNULAR TYPE	ROTATING HEAD
			NO CHANGE UNTIL TIE-BACK			



REVISED	DATE

TSI ThermoSource Inc.

9-5/8" TIE-BACK RUNNING AND CEMENTING PROGRAM

DRAWN FOR:	TRUE
BY:	LFF
DATE:	8/15/87
SCALE:	1"=1000' Vert.
DRAWING No.	006

TYPE OF OPERATION	SLURRY NO.	CEMENT SLURRY USED	SLURRY YIELD CU. FT./SACK	SLURRY WT. LBS/CU. FT.	WATER REQ. CU. FT./SACK
Conductor	1	API Class G and 3% $CaCl_2$	1.15	118	0.67
Surface	2	API Class G and 50# sacks Spherelite and 40% SSA-1 and 5% hydrated lime and 4% gel and 1% CFR-2 and 0.5% Halad 22-A	3.45	82	1.50
Liner	3	Tail in API Class G cement and 3% $CaCl_2$	1.15	118	.67
Liner	2	API Class G and 50# sacks Spherelite and 40% SSA-1 and 5% hydrated lime and 4% gel and 1% CFR-2 and 0.5% Halad 22-A	3.45	82	1.50
Liner	4	Tail in API Class G and 40% SSA-1 and 0.5% CFR-2	1.62	116	.91
Tie Back	4	API Class G and 40% SSA-1 and 0.5% CFR-2	1.62	116	.91
Whipstock Plug	5	API Class G and 40% SSA-1 and 0.75% CFR-2 retarder	1.49	121	.78
Whipstock Plug	6	API Class G and 15% SSA-1 and 15% SSA-2 and 0.75% CFR-2 and retarder	1.28	126	.63

ThermaSource Inc.
P.O. Box 1236 • Santa Rosa, CA 95402

CASING, CEMENTING AND BOP PROGRAMS

CASING PROGRAM | SIZE: 7" | DEPTH: T.D. | L ank and Slotted Liner | WELL: True No. 1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS: TOP BURST	BOT. BURST	COLL.	TENSION
300' - 12,000'	29	L-80	LT & C	S L O T	T E D		3.32

DESIGN CONDITIONS

URFACE BURST PRESSURE	- PSI	OUTSIDE MUD WT. (COLLAPSE)	PPG
INSIDE MUD WEIGHT (BURST)	- PPG	INSIDE MUD WT. (COLLAPSE) -	PPG
UTSIDE MUD WEIGHT (BURST)	- PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -	PPG
FRAC. GRAD. AT SHOE (BURST)	- PPG	BIAXIAL LOAD: COLL. ☐ BURST ☐	BOUYANCY: YES ☐ NO ☐

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

NO CEMENT

	DESIRED TOP	EXCESS

RY VOL. - CU FT / (SLURRY NO.)				
URRY YIELD - CUBIC FEET/SACK				
URRY DENSITY - PPG				
ICKENING TIME - DEPTH SCH/HRS. MIN.				
COMPRESSIVE STRENGTH - PSI/HOURS				

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLARS, AND JOINT STRENGTHENING

1. Hang liner 200' up inside 9-5/8" casing with drill pipe.
2. No centralizers to be run.
3. Locate slots opposite potentially productive zone.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

no cement.
wash performations if necessary.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

no test

PRESSURE TESTING AND LANDING

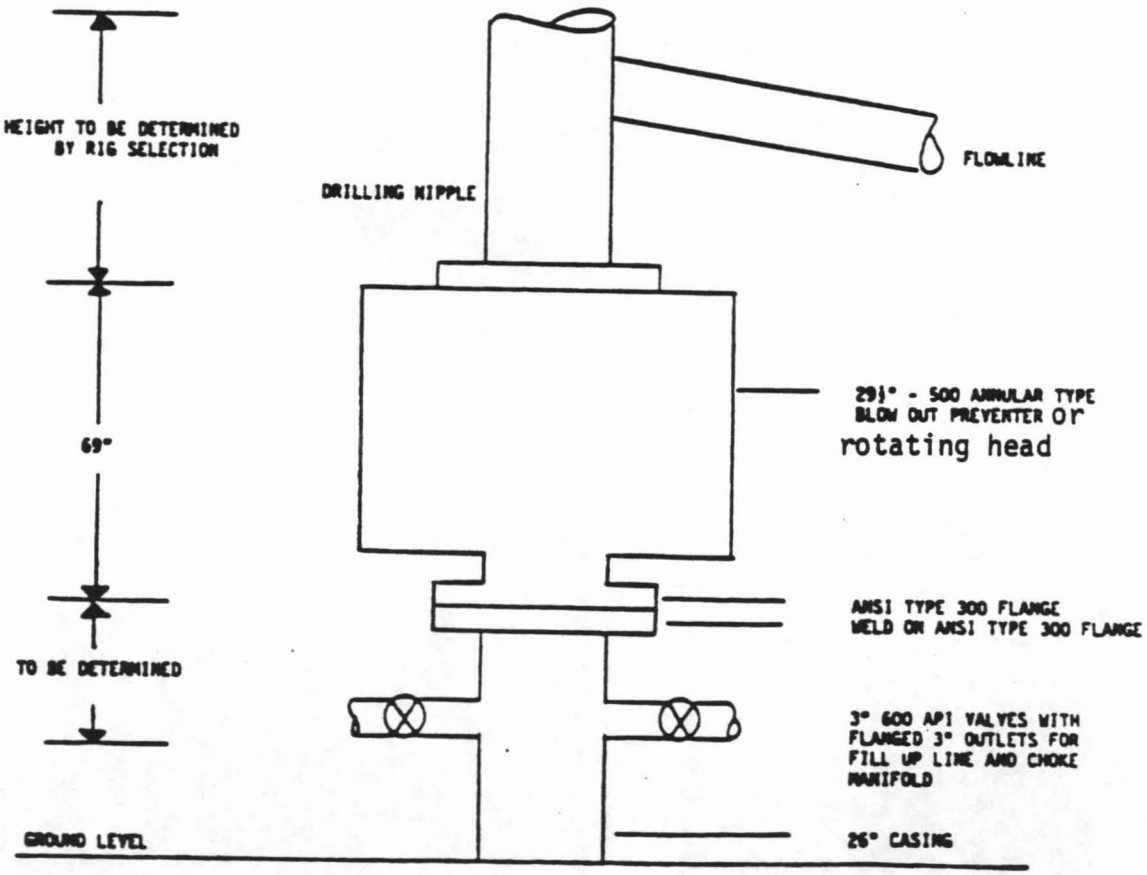
BOP PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI: RAM TYPE	ANNULAR TYPE	ROTATING HEAD
			NO CHANGE IN BLOW OUT	PREVENTERS		

3. Blow Out Preventers

And

Special Considerations

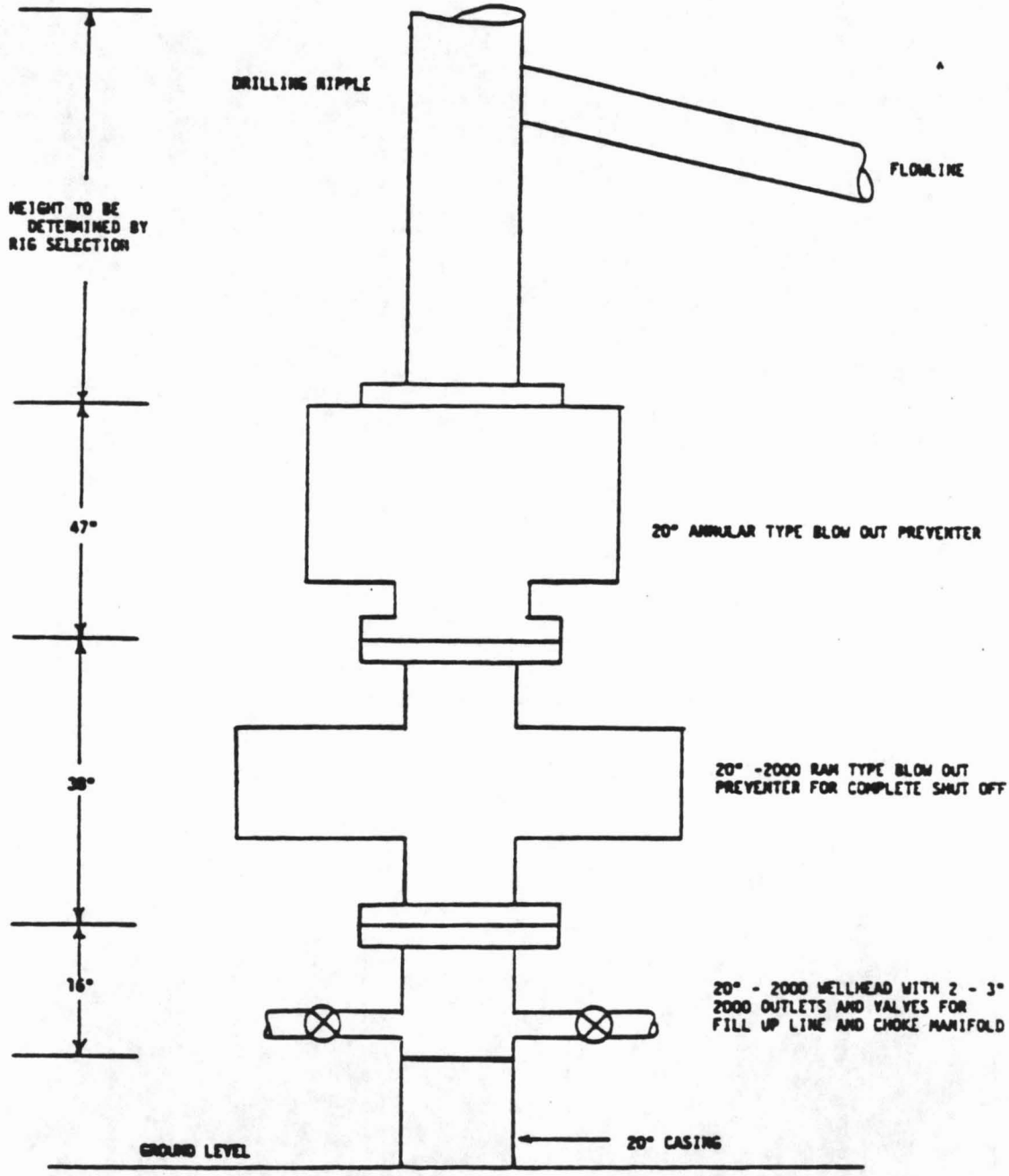


REVISED	DATE

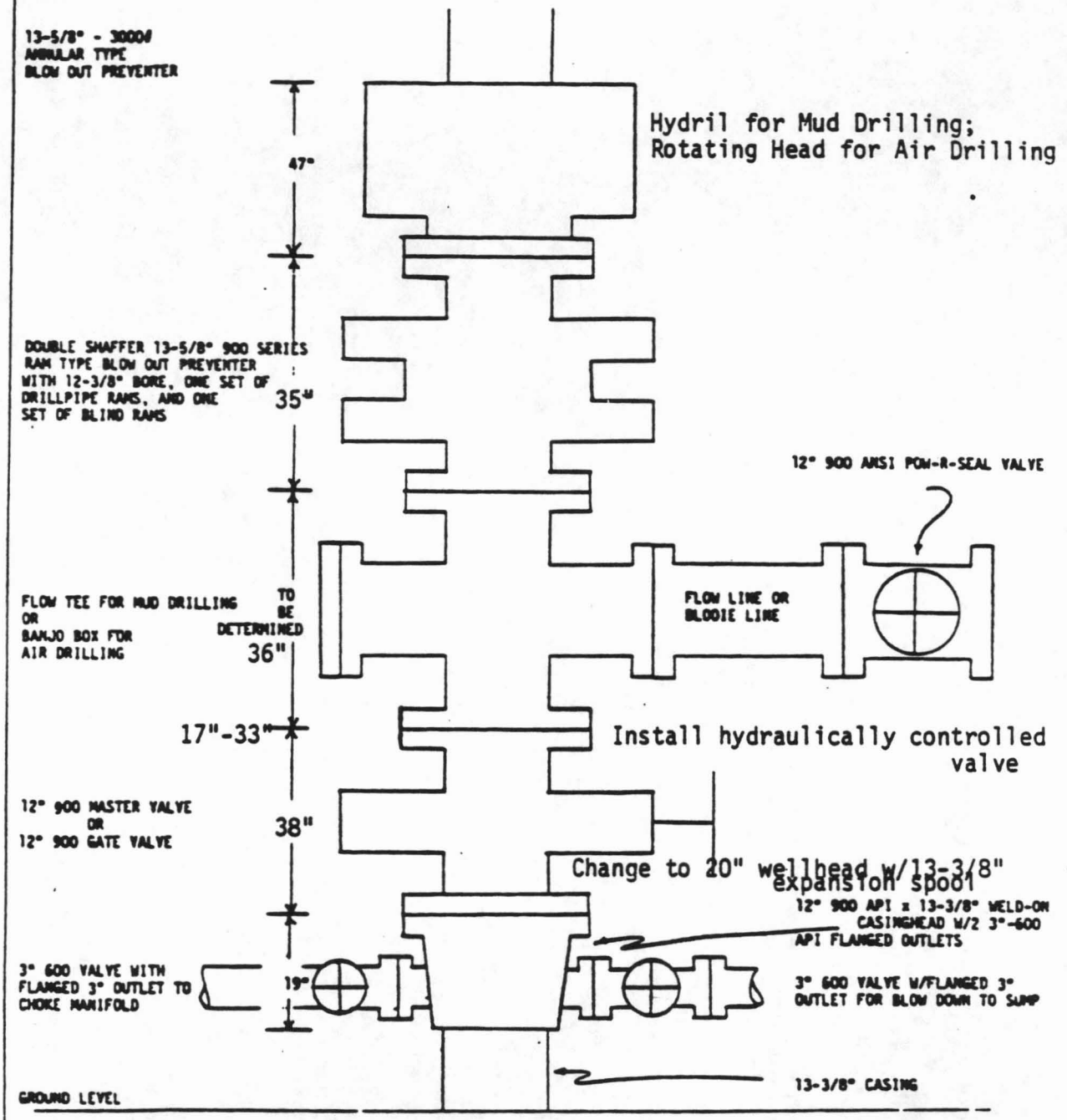
TSI Thermalsource Inc.

BLOW OUT PREVENTER STACK FOR 26" CASING
(This stack may be eliminated with State agency approval)

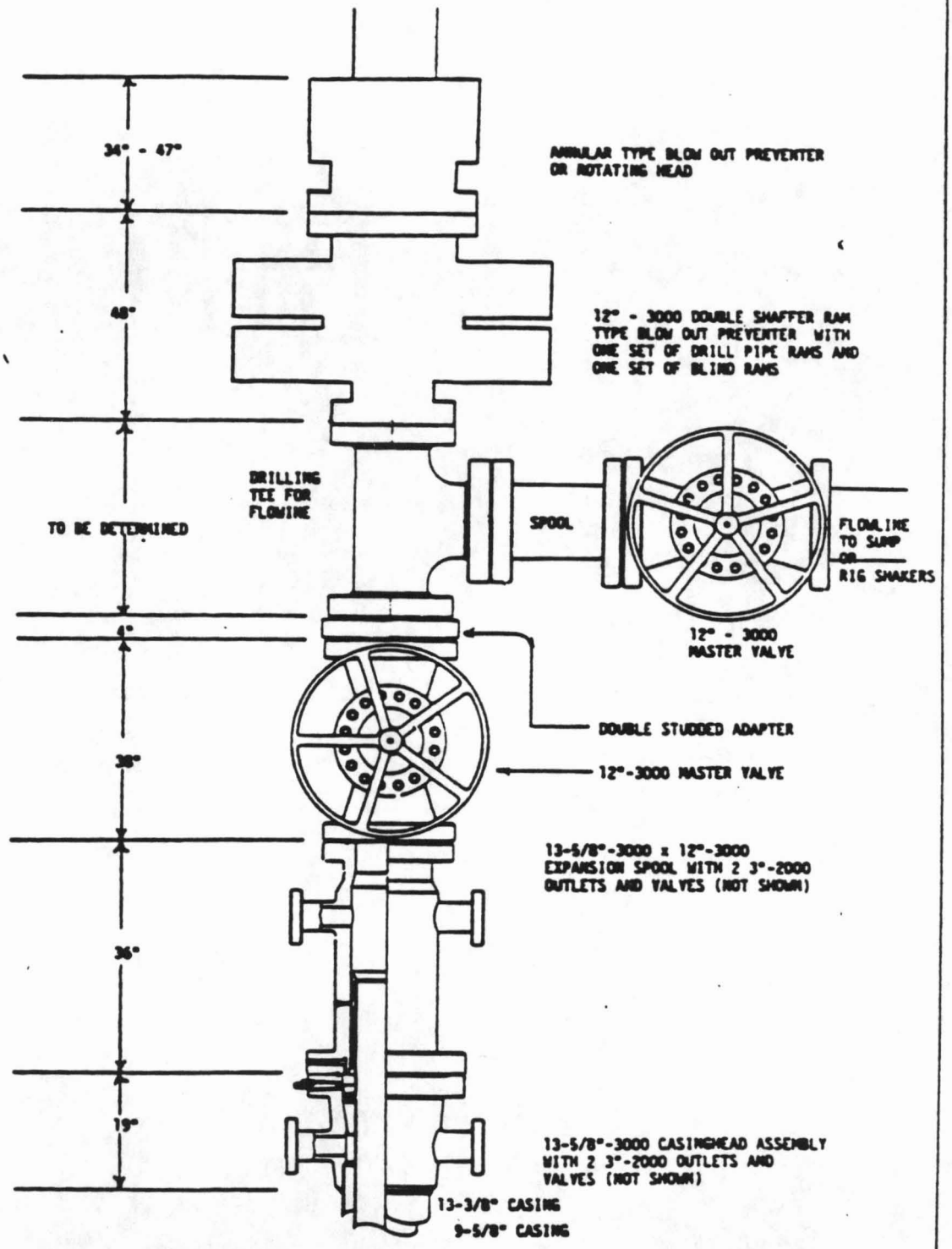
DRAWN FOR: TRUE	
BY: ANG	
DATE: 8/16/87	
SCALE: NTS	
DRAWING No.	007



REVISED	DATE		DRAWN
		TSI Thermal Source Inc.	FOR: TRUE
			BY: ANG
		BLOW OUT PREVENTER STACK FOR 20" CASING	DATE: 8/17/87
			SCALE: NTS
			DRAWING No. 008



REVISED	DATE		DRAWN
		TSI Thermal Sources Inc.	FOR: TRUE
			BY: ANG
		BLOW OUT PREVENTER STACK FOR 13-3/8" CASING	DATE: 8/17/87
			SCALE: none
			DRAWING No. 009



REVISED	DATE		DRAWN
		TSI ThermoSource Inc.	FOR: TRUE
			BY: AMG
		BLOW OUT PREVENTER STACK FOR 9-5/8" CASING WITH EXPANSION SPOOL	DATE: 8/18/87
			SCALE: NTS
			DRAWING No. 010

ThermaSource Inc.
P.O. Box 1236 • Santa Rosa, CA 95402

SPECIAL CONSIDERATIONS

PIPE AND BOP INSPECTION

The initial acceptance of drill pipe should be based on an AAODC-API Class II specification inspection. All subsequent inspections should discard pipe with 30% wear or greater; i.e., use 30% where Class II states 20%.

The drill pipe should include:

1. Electromagnetic inspection of tubes (Sonoscope or Scanalog).

2. Wall thickness and cross sectional area (ultrasonic or gamma ray).

3. End area inspection (electroic or magnetic particle).

All drill collar end areas should be magnetic particle inspected every 14 days, every 9 days in steam or an aerated system.

All BOPs should be inspected for wear by the manufacturer or an authorized agent prior to installation. All BOPs should be tested after installation prior to drilling out cement.

Remind service companies furnishing bottomhole assemblies that their equipment should be magna-fluxed prior to delivery.

AIR EQUIPMENT

Minimum air and pressure requirements are 3000 scfm at 800 psig for rotary drilling. One stand-by unit will be required on the 8-3/4" hole.

Hook-up lines, air meter, and scrubber, misting pump with minimum capacity of 10 gpm, and operating personnel will be furnished by the air contractor. Use Union Oil's Uni Steam corrosion inhibitor while drilling in steam, to be injected into the airline downhole. The mixture for Uni Steam is as follows:

Steam lbs/hr	Injection
None/20,000	5 gal Unisteam - 10/bbl Water
20,000-40,000	10-15 gal Unisteam - 10/bbl Water
40,000-150,000	20-35 gal Unisteam - 10/bbl Water
150,000-plus	40 gal Unisteam - 10/bbl Water

AIR HAMMER INFORMATION

In the event of serious lost circulation or very hard formations, an air hammer may be used. Air hammers are available for various size hole diameters. They require air volumes to operate as follows:

26" Hammer	6000-7000*scfm**@ 160-350 psi
17½" Hammer	3000 scfm @ 160-350 psi
12¼" Hammer	1500 scfm @ 160-400 psi

* This air requirement may be reduced to 2000 scfm by using an accelerator pipe.
** Standard cubic foot (air) per minute

Stabilization is available to maintain a straight hole. Foamer is commonly used to assist hole cleaning when using air hammer.

AUXILIARY EQUIPMENT

1. Six pen drilling recorder with: a) string weight; b) rpm; c) rotary torque; d) rate of penetration; e) pump pressure; f) pump strokes broad.

2. Special rotating head, capable of stripping 12¼" and 8-3/4" BHAs, complete with spare rotating head stripper drive bushing assembly. run cold water continuously on head while in steam.

3. Use square kelly with above.

4. Use tong torque assembly for making up collars.

5. Temperatures should be taken with every directional survey.

6. Install mud loggers as per geologist's instructions.

7. In and out temperatures, both of mud and air, shall be recorded in the Tour Reports every 30 feet prior to rig up of mud loggers. All steam/water entries shall be recorded in the Tour Reports.

8. Periodic tests may be conducted to determine well potential. Drilling will be stopped and the hole evacuated to check for flow.

9. Upon completion, the well will be shut in by closing the lower master valve. The remainder of the BOPE will then be removed.

MASTER VALVE INFORMATION

W-K-M master valve working pressure varies with temperatures of fluids.

900 Series Valve:

No temperature	2160 psi
550° F	1775 psi
600° F	1660 psi
650° F	1550 psi

Outside packing glands should be used above 600° F.

Beveled gear valves should be used.

HYDROGEN SULFIDE MONITORING

Hydrogen sulfide monitoring should be maintained during the drilling of the well. Detectors should be placed on the rig floor, cellar area, and flowline region to detect and announce (with alarms) the presence of hydrogen sulfide. These monitors are typically provided by and maintained daily by the geothermal data loggers. Proper functioning of these monitors is essential in maintaining a safe working environment.

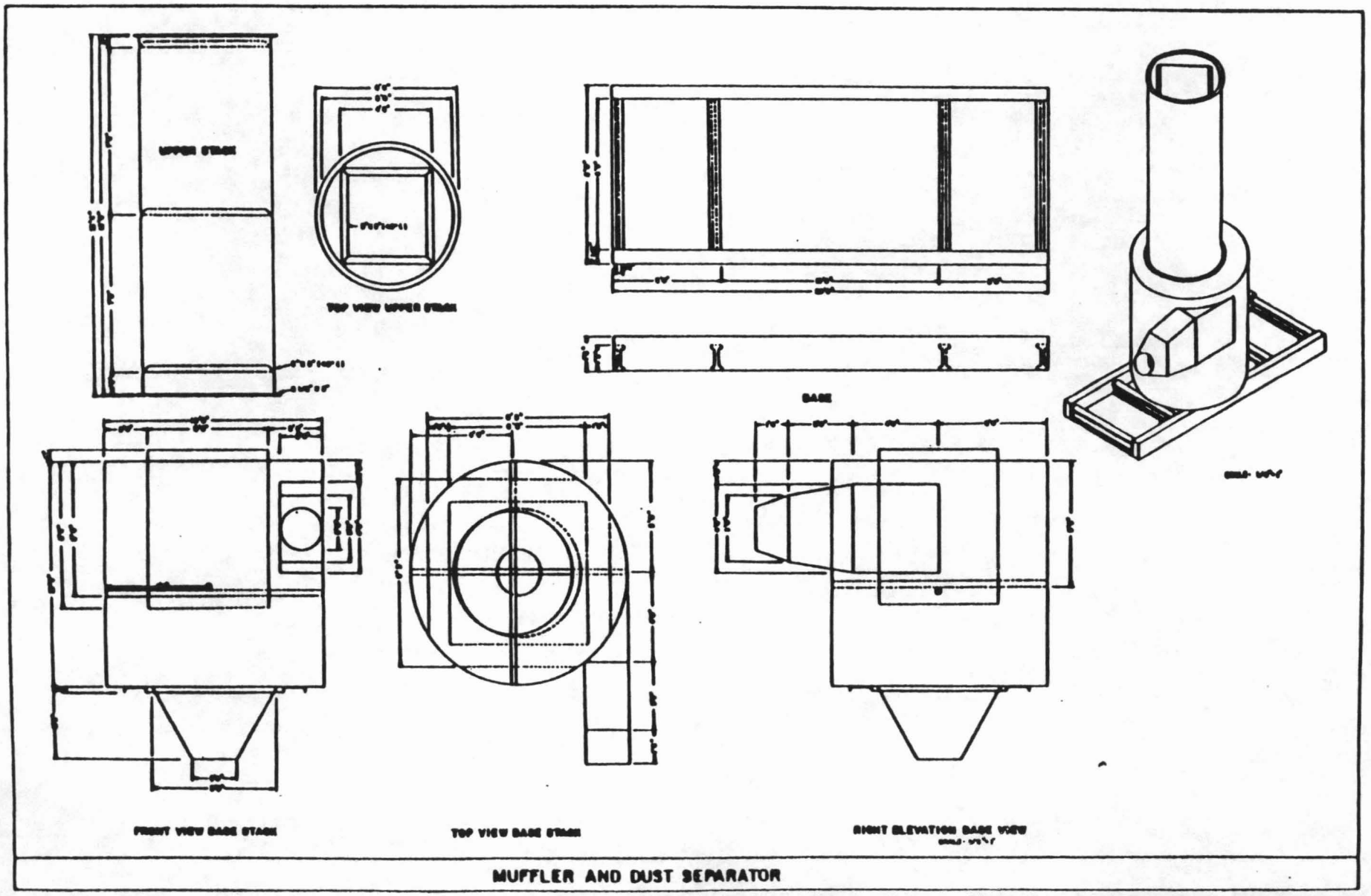
ThermaSource Inc.
P.O. Box 1236 • Santa Rosa, CA 95402

TANGENTIAL MUFFLER

Attached is a drawing of the Tangential Muffler/Separator to be used in True Geothermal-Mid Pacific's geothermal drilling activities. This muffler/separator consists of a large diameter chamber, 10' diameter by 10' tall, with a 6' diameter stack that extends 16' above the 10' chamber. The principle behind this type of device is that the discharge from the well (ambient air circulated downhole and/or steam/water produced from the well) will enter the large diameter chamber tangentially and flow around the chamber, throwing out drilled particles to the side due to centrifugal force in the high velocity air and/or steam exhausted to it. These particles then fall out of the funnel-type structure located at the bottom of the muffler/separator and are channeled to the disposal sump. The air and/or steam must then go down in the chamber to enter the exit stack, the bottom of which sits below the tangential entrance, to be emitted to the atmosphere. The actual blooie line, i.e., the piece of pipe that connects the wellhead and muffler/separator, typically is a piece of 13-3/8" O.D. casing which gradually expands to 36" O.D. and then to a rectangle of a larger cross sectional area than the 36" O.D. pipe. The purpose of this gradual increase is to allow the air and/or steam to expand slowly so as to decrease the noise as much as possible. Water may also be injected, at rates of 60 to 100 gallons/minute, into the muffler/separator as well as the blooie line. The mixing of water with the air/steam exhaust allows some cooling of the steam, which aids in noise reduction. Hydrogen sulfide inhibitors can also be introduced into the exhaust stream upstream of water injection.

Hydrogen sulfide emissions can be abated by the injection of various chemicals into the exhaust stream. Union Oil of California, in conjunction with FMC and Republic Geothermal, Inc., developed a hydrogen peroxide and caustic solution inhibitor that has proven effective in hydrogen sulfide abatement. The hydrogen peroxide and caustic system must be injected in the blooie line as close to the wellhead as possible to give maximum amount of time for the inhibitor to mix with the air/steam discharge.

Continuous monitoring of hydrogen sulfide levels will be made by on-site geothermal data loggers (mud loggers). Metered injections of abatement chemicals to maintain legal emission levels and site safety will also be taken care of by the mud loggers.



MUFFLER AND DUST SEPARATOR

4. Well Testing

WELL TESTING

1. Objectives

Testing a geothermal hot water well should accomplish the following objectives:

A. Evaluate the producing capabilities of the reservoir (aquifer). The well should be produced at or above pre-determined commercial rates to ensure representative samples of the geothermal resource. Surface measurements of mass flow, temperature, and pressure should be monitored. Measuring bottomhole pressures (flowing and shut-in) with downhole recording gauges are desirable but not essential. This data will be used to estimate formation transmissivity, productivity index (PI), and formation damage.

B. Determine properties of the produced fluids. This includes chemical composition, dissolved solids, pH, temperature, enthalpy, and pressure. This data will be helpful in making fluid comparisons between wells to determine aquifer continuity and to anticipate potential long term production problems.

C. Estimate reservoir configuration. Ideally, a well test will provide estimates of long-term producing capability. Unfortunately, the duration of most well tests precludes such estimates unless the reservoir is very small. The well test should be conducted to sample a reasonable drainage area. If any boundaries are located within this area, the pressure buildup should detect it. If the producing formation is a fractured reservoir, then an indication of the well decline rate may be evaluated during a long-term test. Spinner surveys should be considered to determine where the fluids are entering the wellbore.

2. Types of Tests

Several types of well tests are available to satisfy all or part of the test objectives.

A. Rig Test. This is a short term test, usually 24 hours, performed with the drilling rig and equipment in place. Well fluids are sent through a flow line from the well tree assembly to a drilling reserve pit. A choke plate or throttling valve can be installed in the flowline to control flow. Pressure is measured at the end of the flowline (James Lip Pressure) to obtain an estimate of mass flow. Wellhead pressures and temperature should also be measured. A rig test is normally used while drilling after geothermal fluids are encountered to monitor flow rates as a function of depth. It is a quick and simple way to get reservoir flow data for future decision making. The main drawback to this method is that steam quality cannot be estimated.

B. Short Term Test. Short term is defined as less than a month. This procedure involves using a steam/water separator to accurately determine liquid and vapor fractions. The data gathered during this type of test would satisfy all of the objectives listed above. Figure 1 shows a schematic of how the test would be conducted. Fluids would leave the wellhead and go into a separator. The mass flow of each phase would be measured. After the flow is completed, the well should be shut-in and bottomhole pressure measured. If adjacent wells have been drilled, their pressures should be monitored during the test to check for drawdown effects. Additional flow tests may be conducted at different pressures to verify steam quality changes and flow rate variations. In most cases, a short term test is sufficient to describe most of the reservoir parameters of interest.

C. Long Term Test. A long term test is defined as one lasting over one month. Data from a long term test will provide some insight into the time dependency of certain variables such as mass flow, steam quality, and fluid chemistry. A long term test could also quantify well interference effects. It may also detect phase changes that may occur in reservoirs and provide some insight into the size and longevity of the reservoir. Data from a long term test can also be used as a basis for reservoir modeling for long term predictions of well and

reservoir performance. Long term tests may even be coordinated with equioment tests of wellhead generators or abatement equipment. The equipment and procedures to conduct a long term test would be the same as a short term test.

D. Drill Stem Test. Drill stem tests are commonly used in oil and gas wells as a means of obtaining well information. Its primary advantage over a simple rig test is that some control is exercised over the zones that are produced. The risk in drill stem testing, particularly in high termperature wells, is packer failure.

3. Recommended Test Procedure for True Geothermal Well No. 1

During drilling and/or immediately after total depth has been reached, a rig test is recommended to determine whether the well is commercial and if further testing is appropriate. If the results of the rig test are positive, then a short term test can be arranged. If the rig tests are negative, new drilling plans to sidetrack or to change locations can be made. Tests should be planned to comply with applicable water, air, and noise regulations. Information obtained during the rig test will be helpful in selecting the proper pressure vessels, piping, and measuring devices needed to perform a rigorous well test.

A long term test may be considered after the short term test has been completed if additional data is required.

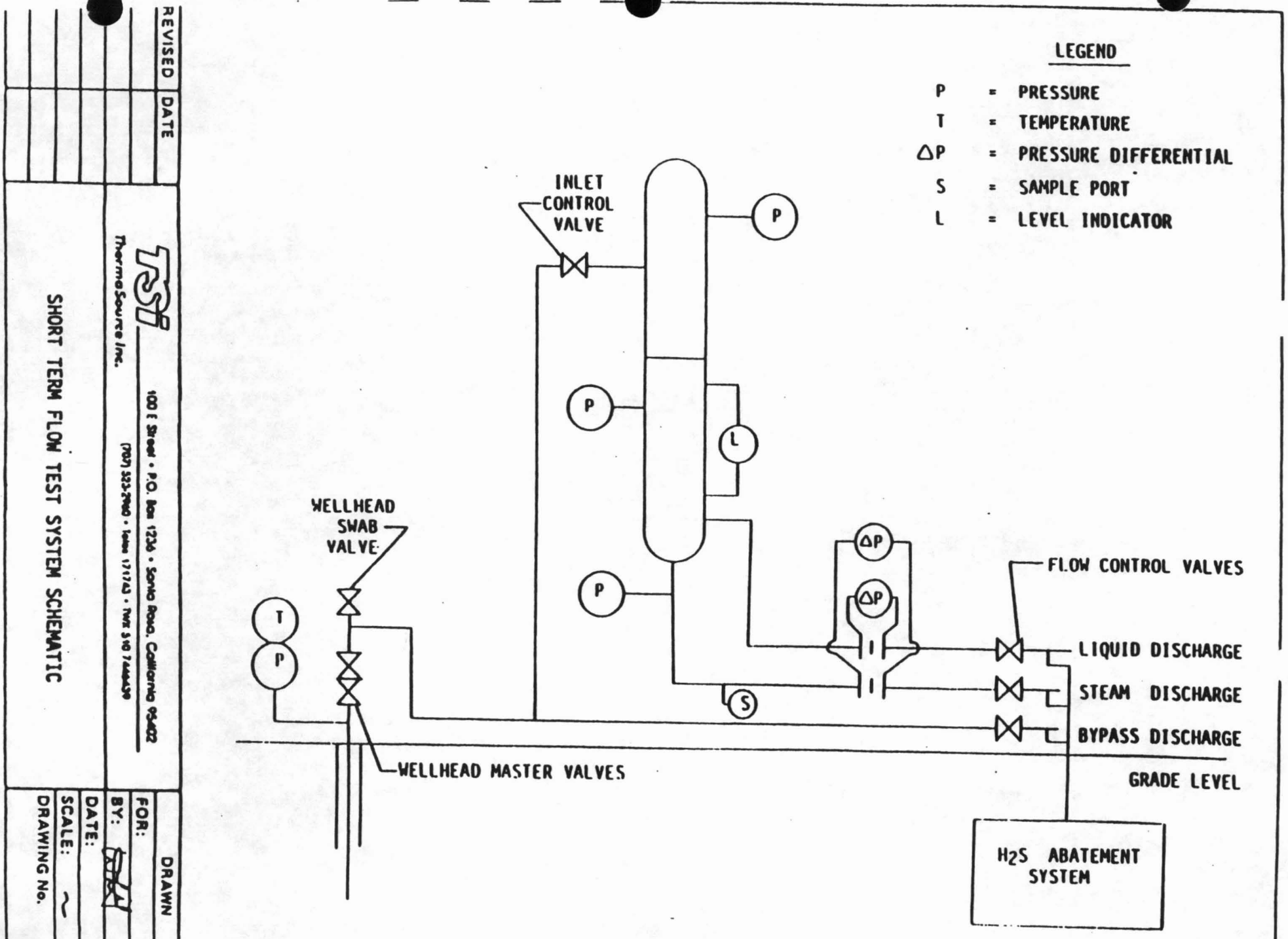

LEGEND
P = PRESSURE
T = TEMPERATURE
ΔP = PRESSURE DIFFERENTIAL
S = SAMPLE PORT
L = LEVEL INDICATOR
INLET CONTROL VALVE
WELLHEAD SWAB VALVE
WELLHEAD MASTER VALVES
FLOW CONTROL VALVES
LIQUID DISCHARGE
STEAM DISCHARGE
BYPASS DISCHARGE
GRADE LEVEL
H2S ABATEMENT SYSTEM
REVISED
DATE
DRAWN
FOR:
BY:
DATE:
SCALE:
DRAWING No.
SHORT TERM FLOW TEST SYSTEM SCHEMATIC
ThermoSource Inc.
100 E Street • P.O. Box 1236 • Santa Rosa, California 95402
(707) 523-2900 • Telex 171743 • TWX 910 7448439

FIGURE 1

HN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

GEOTHERMAL WELL DRILLING PERMIT

True/Mid-Pacific Well KA2-1

TO: True Geothermal Energy Company
Central Pacific Plaza
220 South King Street, Suite 868
Honolulu, Hawaii 96813

Your application dated October 30, 1991, for a permit to drill a geothermal well on lands located within the Kilauea Middle East Rift Geothermal Resource Subzone and covered under the State of Hawaii, Geothermal Resource Mining Lease No. R-5 is approved.

Well Designation: True/Mid-Pacific Well KA2-1
Location: TMK 1-2-10:03, Puna, Hawaii
Leased to: Estate of James Campbell (GRML R-5)
Subleased to: True/Mid-Pacific Geothermal Venture
Operator: True Geothermal Energy Company
Ground Elevation: 1,440± ft.
Total Depth: 12,000 feet

You are hereby granted permission to drill the geothermal well described above and in your application in accordance with the Department's Administrative Rules, Chapter 13-183, HAR, and under the following conditions:

(1) All work shall be performed in accordance with the permission and terms of the occupiers of the land, the Drilling and Completion Program submitted with your application, the Department's Administrative Rules (Chapters 13-183 and 13-184, HAR), and all other applicable Federal, State, and County laws, ordinances, rules, and regulations;

(2) The permittee, its successors and assigns shall indemnify, defend, and hold the State of Hawaii harmless from and against any loss, liability, claim or demand for property damage, personal injury and death arising out of any act or omission of the applicant, assigns, officers, employees, contractors and agents under this permit or relating to or connected with the granting of this permit;

(3) The permittee shall observe and comply with all valid requirements of County, State, and Federal authorities and regulations pertaining to the lands and permittee's operations including, but not limited to, all water and air pollution control laws and those relating to the environment;

(4) The applicant shall observe and comply with all requirements and conditions as set forth in the Board of Land and Natural Resources' Decision and Order dated April 11, 1986;

(5) No well shall be sited within 3,500 feet of the eastern boundary of the property line near Kaohe Homesteads, nor within 3,500 feet of the southeastern boundary of the property line near upper Kaimu Homesteads;

(6) The well and bottom-hole location shall be located more than 100 feet from the outer boundary of the parcel of land on which the well is situated, or more than 100 feet from a public road, street, or highway dedicated prior to the commencement of drilling, unless modified by the Chairperson upon request;

(7) The permittee shall notify the Division of Water Resource Management (DWRM), in writing, of the date of the start of work;

(8) Prior to drilling, the permittee shall submit to the Department the bottom-hole target location and direction of any proposed deviation;

(9) All blow-out prevention equipment (BOPE) and cemented casing strings shall be pressure tested before commencing any other operations on the well. Test pressures shall not be less than 600 pounds per square inch nor greater than 1,500 pounds per square inch, and shall be applied for a period of thirty minutes. The results of the pressure tests shall be reported on forms provided by the Department.

If a drop of more than ten percent of the casing test pressure is recorded, the operator shall then run a caliper log and/or other appropriate well test to determine if the casing is defective and if corrective measures will be required before commencing any further operations. The results of the prescribed casing tests and any remedial work conducted shall be submitted to the Department within sixty days after completion;

(10) Class "G" cement shall be used in the casing cementing operations and shall contain a high temperature resistant admix;

(11) A real time monitoring device must be installed for the driller and a pit alarm system should be included with this monitoring device. All toolpushers, drillers, and derrickmen should be schooled in the use of the recommended monitoring equipment.

(12) If changes to the proposed drilling program are contemplated, the permittee shall obtain the Chairperson's approval before executing such changes;

(13) When drilling has reached a depth of not more than 50 feet below sea level, the Department's representative shall be notified, with reasonable time allowed for travel to the site, to witness the retrieval of a representative groundwater sample and the measurement of the static water level. The permittee shall have the sample analyzed by an independent laboratory and have the results submitted to the Department;

(14) During the use of the well for testing, monitoring, production and/or injection purposes, the well and site shall be properly maintained until the well is plugged and abandoned in accordance with the Department's Administrative Rules, Chapter 13-183, HAR;

(15) The permittee shall submit to the Chairperson, the results of any exploration, all drilling and testing records, down-hole surveys of the well, bottom-hole location, date of completion, and a survey of the well location and elevation above mean sea level taken by a Hawaii licensed surveyor within six months after completion of the well;

(16) A well completion report, an as-built drawing of the well, and the location of the well plotted on an U.S.G.S. quad scale map shall be filed with the Department within six months after completion of the well;

(17) The bond covering the well shall remain in full force and effect until the well is properly abandoned and the surface is restored as near as possible to its original condition; and

(18) This permit shall expire 365 days from the date of issuance.

WILLIAM W. PATY, Chairperson

DEC 13 1991

Date of Issuance

cc: Land Board Members
Hawaii County Planning Dept.
DBEDT
Department of Health
OEQC

992

Wrm

TRUE GEOTHERMAL ENERGY COMPANY

CENTRAL PACIFIC PLAZA
220 South King Street
Suite 868
Honolulu, HI 96813

Telephone No.: 808-528-3496
FAX No.: 808-526-1772

91 OCT 1 A9:29

DIV. OF WATER & LAND DEVELOPMENT

October 30, 1991

Mr. William Paty
Director
Department of Land and Natural Resources
State of Hawaii
1151 Punchbowl Street, Room 224
Honolulu, Hawaii 96813

ATTN: Mr. Manabu Tagomori

SUBJECT: SUBMISSION OF DRILLING PROGRAMS FOR DRILL OR WELL SITES NUMBERS 2 AND 3, KILAUEA MIDDLE EAST RIFT ZONE, PUNA, HAWAII

Dear Mr. Paty:

Enclosed are the proposed drilling programs for True Geothermal Energy Company's drill sites numbers 2 and 3. The programs were prepared pursuant to the requirements of the Department of Land and Natural Resource's Rules on Leasing and Drilling of Geothermal Resources (Title 13, Subtitle 7, Chapter 183). We wish also to incorporate by reference the information contained in our permit to drill sent to the engineers of DLNR by letter dated February 1, 1989. The locations of drill sites numbers 2 and 3 are noted on a map sent to DLNR by letter dated October 23, 1991.

The programs were prepared in consultation with ThermaSource, Inc., who have acted as our drilling consultants for the past ten years.

Your review and concurrence are respectfully requested for the submittals. Should you have any questions please call me at 528-3496 or Mr. Gerald Niimi of ThermaSource, Inc., at (707) 523-2960. Thank you for your attention.

Very truly yours,

TRUE GEOTHERMAL ENERGY COMPANY

Allan G. Kawada

AGK/reg

encl.

ThermaSource INC.
GEOTHERMAL CONSULTING SERVICES

TRUE GEOTHERMAL ENERGY COMPANY
KMERZ WELL NO. KA2-1
GEOTHERMAL DRILLING PROGRAM
COUNTY OF HAWAII

Submitted to:

Department of Land and Natural Resources
Honolulu, Hawaii

October 1991

725 Farmers Lane • P.O. Box 1236 • Santa Rosa, California 95402 • (707) 523-2960 • FAX (707) 523-1029

TRUE GEOTHERMAL ENERGY COMPANY
KMERZ WELL NO. KA2-1
GEOTHERMAL EXPLORATION WELL PROGRAM

The following well program is designed to drill and complete a nominal 10,000′ geothermal exploration well in the KMERZ. (See Figure 001) Based on the results of prior drilling, a large degree of flexibility is built into the program. It should be clear that being an exploration well, the casing setting depths and drilling procedures are subject to change at any time. DLNR will be notified and updated as drilling progresses on any changes.

1. Install 30" conductor pipe in 42" hole to 60′ to 100′ or as deep as possible below ground level prior to rotary rig moving onto location. Cement conductor from total depth back to surface with redi-mix cement. If a burial cave or lava tube is encountered when setting the conductor pipe, further investigation is required prior to proceeding. Notify DLNR and consult with archaeologist. If conditions warrant, conductor installation may also be performed with rotary rig.

2. Construct 10′ x 10′ x 9′ deep cellar around conductor pipe with a cemented bottom and stairway exit toward front of rig. See attached Figure 002.

3. Move in rotary drilling rig to drill well. Center rig over conductor pipe and rig up. Drill 42" hole with bucket bit and install 30" conductor, if not installed prior to moving in. Add 30" OD extension to conductor pipe to bring it up under rotary table. Install flow line on conductor pipe to return mud to pits.

4. Notify DLNR upon startup of drilling of a pilot hole. Pick up an 8-1/2" bit on a 26" hole opener or reamer and run into the bottom of the conductor pipe. Center punch 8-1/2" hole and drill 8-10′. Pull out of hole and remove 26" hole opener or reamer. Run 8-1/2" bit and drill to 100′+/-. During the drilling of this 8-1/2" pilot hole progress should be monitored constantly to determine if a lava tube which may contain archaeological artifacts might be encountered directly under the rig. If the bit drops free for more than eight (8) feet then drilling will stop. If this drop occurs the hole will be flushed with clear water and a light source with video camera lowered into the hole to investigate the possibility of any archaeological value. If archaeological value is determined then drilling will stop and the rig moved. If no archaeological value is determined then provisions would be made to continue drilling. Drilling supervisor shall be on drill rig floor throughout complete pilot hole drilling operations.

5. Open 8-1/2" hole to 26" with 26" bit and drill with mud to 800-1000′ depending on geology. Maintain hole as straight as

possible, take drift shots every 100'. Maximum rate of change 1 degree per 100'. Install mud loggers at surface to log entire well from 0' to total depth. Catch three clean and dry samples every 10'.

6. Rig up and run 20" casing to total depth as per attached 20" casing program with 20" stab-in float collar and float shoe on bottom.

7. Once 20" casing has been run to bottom, run in hole with stab-in tool on bottom of drill pipe and stab into float collar. Circulate hole clean with at least two full circulations.

8. Cement 20" casing through drill pipe as per attached program. Circulate cement back to surface between 20" and 30" casing. Observe cement level. If cement falls back in annulus, bring same back to surface with 1" pipe.

9. Wait on cement 8 hours.

10. Land 20" casing. Cut off and remove 30" conductor drilling nipple. Cut off 20" casing and weld on 20" S.O.W. x 21-1/4" 2000 psi wellhead. Install two 3" valves. Install 20" blow out preventer equipment as per attached Figure 003.

11. Test 20" casing and blow out preventer equipment to 1500 psi for 30 minutes.

12. Drill out cement and float collar and float shoe from 20" casing with 17-1/2" bit using mud. Drill 30' of formation and trip to pick up stabilization.

13. Continue to drill 17-1/2" hole as vertical as possible with mud to 3500'+/- as indicated by formation. Directionally survey well at least every 100'. If lost circulation presents severe problems, an aerated mud system may be utilized. Severe loss circulation zones should be cemented off prior to drilling ahead.

14. Once 17-1/2" hole has been completed to casing point, rig up and run logs if indicated by geologic staff.

15. Upon completion of logging program, run in hole with bit and circulate to condition hole for casing.

16. Rig up and run 13-3/8" casing as per attached 13-3/8" casing program and running procedure. If lost circulation presents severe problems during drilling it may be necessary to set 13-3/8" pipe as a liner then tie it back to the surface rather than a full string of casing. See running procedure for alternative options.

17. Cement 13-3/8" casing as per attached program. Circulate cement back to surface between 13-3/8" and 20" casings. Observe cement, if it falls back, bring level back to surface using 1" pipe.

18. Wait on cement 12 hours or until samples are set.

19. Land 13-3/8" casing. Remove 20" blow out preventer stack. Cut off 13-3/8" casing and install 12" x 21-1/4" 900 ANSI expansion spool wellhead with two 3" flanged outlets equipped with 3" 2000 psi wing valves. Install 12" 900 series blow out preventer stack with 12-1/4" bore as per attached Figure 004.

20. Test 13-3/8" blow out preventer stack to 1500 psi for 30 minutes.

21. Drill out all cement, float collar and shoe from the 13-3/8" casing with a 12-1/4" bit using mud. Drill 30' of formation and trip to pick up stabilization.

22. Drill 12-1/4" hole with mud or aerated mud as required by hole conditions to 6000-8000', the 9-5/8" casing point, as indicated by geologic staff. Lock up drilling assembly to maintain direction and angle as straight as possible to casing point.

23. Once 12-1/4" hole has been completed to casing point, rig up and run logs if indicated by geologic staff.

24. Upon completion of logging program, run in hole with bit and circulate to condition hole for casing.

25. Rig up and run 9-5/8" casing as a liner equipped as required with external casing packer located 200-300' from bottom. Hang same using a double slip liner hanger with tie-back sleeve. Run 9-5/8" liner from total depth to hanger located 200' up inside of 13-3/8" casing as per attached 9-5/8" liner program and running procedure.

26. Once liner is hung, circulate hole clean through drill pipe with at least two full circulations.

27. Cement 9-5/8" liner and external casing packer from total depth back up to top of liner lap as per attached cementing program.

28. Once cement is in place, disengage from liner hanger and pull up 60' and circulate out excess cement.

29. Pull out of hole with liner hanging tool and run in hole with 12-1/4" bit and drill out cement from 13-3/8" casing to top of 9-5/8" liner lap. Test lap to 1000 psi only after cement has been in place 12 hours. Squeeze lap area if necessary to

obtain a 1000 psi squeeze pressure.

30. Trip for 8-1/2" bit and drill out excess cement from 9-5/8" liner down to top of float collar. Pressure up and retest 13-3/8" casing, liner lap and 9-5/8" casing to 1000 psi.

31. Drill out cement, float collar and float shoe from 9-5/8" casing using 8-1/2" bit and mud. Drill 30' of formation and circulate to change out mud for water. Re-install rotating head on blow out preventer stack for air drilling if not already installed for the drilling of the 12-1/4" hole.

32. Trip to pick up 8-1/2" stabilization. Drill 8-1/2" hole through production zone to total depth of 9,000'-12,000' using air or aerated water as a drilling medium.

33. Pull out of hole with drill pipe and test well for short term with rig on location.

34. If results appear commercial, pull out of hole and release rig for long production test or proceed ahead with attached 9-5/8" tie-back procedure to complete well with 9-5/8" tie-back, if 13-3/8" casing shows damage or excessive wear. If well test results prove that the flow rate from the well is not commercial then either deepen or redrill to obtain production.

35. Evaluate well and complete with either open hole or 7" slotted liner.

SPECIAL CONSIDERATIONS
AUXILIARY EQUIPMENT THAT SHOULD BE MAINTAINED WITH THE RIG

1. Six pen drilling recorders on drill floor with: a) string weight; b) rpm; c) rotary torque; d) rate of penetration; e) pump pressure; f) exit pressure. Additional real time monitoring of drilling parameters to be considered upon consultation with DLNR Staff.

2. Special rotating head with rubbers, capable of stripping 17-1/2", 12-1/4" and 8-1/2" bottomhole assemblies. Complete with spare rotating head stripper drive bushing assembly. Rotating head should be installed on top of hydril or at least on location, available for installation if necessary. Run cold water continuously on head while producing geothermal fluids.

3. Use tong torque assembly with torque gauge for making up collars to API torque requirements.

4. Temperature should be taken with every directional survey by running a maximum recording thermometer in the survey instrument.

5. Catch drill cutting samples (3 sets) every 10', to be cleaned and sacked.

6. In and out temperatures, both of mud, air or aerated water, shall be recorded in the Tour Reports every 30'. All steam/water entries shall be recorded in the Tour Reports.

7. All lost circulation zones encountered shall be recorded in Tour Book recording both the depth at which the loss occurred, as well as the amount of fluid lost. All flows shall also be recorded giving depth and the amount of increase.

8. Periodic tests may be conducted to determine well potential. Drilling will be stopped and the hole evacuated to check for flow at lost circulation zones.

9. Upon completion, the well will be shut in by closing the lower master valve. The remainder of the blow out preventer equipment will then be removed.

10. Rotary table will be equipped with a torque gauge with visual display for driller.

HYDROGEN SULFIDE MONITORING AND ABATEMENT

Hydrogen sulfide monitoring should be maintained during the drilling of the well. Detectors should be placed on the rig floor, cellar area, and flowline region to detect and announce (with alarms and lights) the presence of hydrogen

sulfide. These monitors are typically provided by and maintained daily by the geothermal data loggers. Proper functioning of these monitors is essential in maintaining a safe working environment.

Hydrogen sulfide abatement equipment and materials, i.e. pumps and caustic soda, should be maintained on location when drilling with lighter than water drilling fluids, i.e. air or aerated mud systems.

Escape breathing equipment, as well as resuscitators shall be available on site with mud logging unit. Fans should also be available on the rig floor to clear H2S contaminated floor areas, making it safer to work.

PIPE AND BLOW OUT PREVENTER INSPECTION

The initial acceptance of drill pipe should be based on an IODC-API Class II specification inspection. All subsequent inspections should discard pipe with 30% wear or greater; i.e., use 30% where Class II states 20%.

The drill pipe should include:

1. Electromagnetic inspection of tubes (Sonoscope or Scanalog).

2. Wall thickness and cross sectional area (ultrasonic or gamma ray).

3. End area inspection (electronic or magnetic particle).

All drill collar end areas should be magnetic particle inspected every 14 days or every 9 days while drilling with production or drilling with air or aerated mud systems.

All BOPs should be inspected for wear by the manufacturer or an authorized agent prior to installation. All BOPs should be tested after installation prior to drilling out cement.

Remind service companies furnishing bottomhole assemblies that their equipment should be magna-fluxed prior to delivery.

AIR EQUIPMENT REQUIREMENTS

Minimum air and pressure requirements are 4500 SCFM at 1000 psig for rotary drilling 12-1/4" hole below 13-3/8" casing.

Minimum air and pressure requirements are 3000 SCFM at 1000 psig for rotary drilling below 9-5/8" casing.

Hook-up lines, air meter, and scrubber, misting pump with minimum capacity of 10 gpm, and operating personnel will be furnished by the air contractor. Use Union Oil's UniSteam corrosion inhibitor while drilling in steam, to be injected into the drill pipe. The mixture for UniSteam is as follows:

Steam lbs/hr	Injection
0-20,000	5 gal UniSteam-10/BBl water
20,000-40,000	10-15 gal UniSteam-10/BBl water
40,000-150,000	20-35 gal UniSteam-10/BBl water
150,000+	40 gal UniSteam-10/BBl water

PROCEDURE FOR RUNNING AND CEMENTING 13-3/8" CASING

1. Drill to casing depth.

2. Circulate for 2-3 hours, two complete circulations to clean hole of cuttings.

3. Pick up excess drill pipe needed to stab into float collar for cementing the 13-3/8" casing.

4. Make short trip and circulate for 1-2 hours.

5. Pull out of hole and rig up to run 13-3/8" casing. Run multi-shot survey while pulling out of hole if necessary. If loss circulation has not been a severe problem in drilling the 17-1/2" hole, then proceed ahead to step 8 and run 13-3/8" casing as a full string. If loss circulation has presented problems, then proceed to step 23 and run 13-3/8" as a liner with tie-back string.

6. Run 13-3/8" casing grades, weights and thread design as indicated on attached detailed sheet with stab-in collar 40' from float shoe on bottom with centralizers located one in middle of bottom two joints and then one every other collar upward omitting any from the top 200'.

7. Set casing in elevators on spider. Do not set casing slips. Drop centralizing ring of 13-3/8" casing inside 20" wellhead. Install return hoses from 20" wellhead to mud pits.

8. Rig up with landing plate on top of 13-3/8" casing. Run drill pipe into 13-3/8" with stab-in sub on bottom. Stab into collar and rig up to circulate. Tie down drill pipe.

9. Circulate for 3 hours, or at least two full circulations, to clean up and cool down hole.

10. Rig up to cement.

11. If loss circulation is a problem, pump 20 BBls CaCl2 water, 10 BBls fresh water, 20 BBls sodium silicate, followed by 20 BBls viscous Geo-Gel mud spacer.

12. Pump cement without any additional spacers. Pump stage 1 consisting of Class G perlite blended 1:1 with 40% silica flour, 3% gel and 0.5% CFR-2. Retard as needed. Pump this cement until you see returns of cement at the surface. If loss circulation has been a problem, the cement may have to be changed to a spherelite blended cement, see Note below.

13. Pump stage 2 cement: Class G cement with 40% silica flour, 3% gel and 0.5% CFR-2. Retard as needed. Pump 200 cu ft of this stage 2 cement. The last 100 cu ft should be staged in: Pump 35 cu ft and shut down for 5-10 minutes, then pump 35 cu

ft and shut down again for 5-10 minutes before pumping last 30 cu ft. Check for fall back in annulus each time. Pull out of stab-in shoe and clear drill pipe, dropping all excess cement from drill pipe on top of float collar.

14. Rig down circulating equipment and pull out of hole with drill pipe.

15. Hook up to 13-3/8" casing elevators and pick up slightly to remove spider, then center 13-3/8" casing in stack.

16. Drain blow out preventer equipment after 30 minutes from the time cement was in place.

17. Wait on cement 12 hours before landing casing. Check for cement fall back in annulus periodically. Bring cement back to surface using 1" pipe if necessary.

18. Cut off 13-3/8" casing. Remove 20" blow out preventer equipment. Install 21-1/4" x 12" 900 ANSI expansion spool, 12" master valve and nipple up blow out preventer equipment as in attached Figure 004.

19. Test blow out preventer equipment to 1000 psi. BOPE Program Says 1500 psi

20. Change out bottom hole drilling assembly for 12-1/4" tools and run in hole.

PROCEDURE FOR RUNNING & CEMENTING 13-3/8" AS A LINER AND TIE-BACK STRING

1. Follow steps 1-4 above.

2. Pick up 13-3/8" liner. If circulation was never achieved, then a stage collar should be installed at approximately 2000'. Install cement basket type centralizers in the middle of the bottom two joints and one just below stage collar. Install one cement basket type centralizer to be located 20' up inside 20" casing shoe.

3. Run liner in hole and hang same 100' up inside of 20" casing with shoe just off bottom.

4. Attempt to circulate with two times total volume of fresh water. If unsuccessful, then proceed with cement job.

5. Pump 20 BBls CaCl2 water and 10 BBls fresh water, followed by 20 BBls sodium silicate, 20 BBls Geo-Gel flush, then cement slurries for stage 1. Follow stage 1 cement with 200 cu ft of stage 2 cement.

6. Release plugs after stage 2 cement and open cementing ports if stage collar is run.

7. Circulate through stage collar. Repeat preflush prior to pumping cement. Pump stage 1 and stage 2 cement as in prior cement job on bottom section of 13-3/8" liner.

8. Release plugs and displace cement and plugs down hole to close stage collar.

9. Release hanger and pull out of hole with setting tool. Wait on cement for 6 hours.

10. Run in hole with 17-1/2" bit and clean out excess cement, if any, from the top of the 13-3/8" liner.

11. Test lap to 750 psi. If unable to get a test, trip to lay down bit, run in open ended. Squeeze lap with Class G cement blended with 40% silica flour and 0.5% CFR-2 using pipe rams.

12. Re-squeeze until a squeeze pressure is achieved. Fill hole with water.

13. Drill out excess cement with 17-1/2" bit and retest lap to 750 psi.

14. If successful in testing lap, run in hole with 12-1/4" bit and 13-3/8" casing scraper to clean out tie-back sleeve.

15. Pick up 13-3/8" tie-back with float collar located 40' above tie-back stinger on bottom.

16. Run tie-back string in hole and land same in sleeve at hanger.

17. Circulate around with fresh water, then run cement slurry. Use top plug only.

18. Wait on cement 6 hours. If after 6 hours cement is not to surface level in 13-3/8" x 20" annulus, insert 1" tubing and bring it back to surface with cement.

19. Cut off 13-3/8" casing. Remove 20" blow out preventer equipment. Install 21-1/4" x 12" 900 ANSI expansion spool, 12" master valve, and nipple up blow out preventer equipment as in attached Figure 004.

20. Test blow out preventer equipment to 1000 psi for 30 minutes.

21. Change out bottom hole drilling assembly for 12-1/4" tools and run in hole.

NOTE: Spherelite cement should be blended as follows:

Class G cement blended with 40% silica flour, 50 lbs per sack of cement of spherelite, 4% gel, 5% lime, 1.25% CFR-2, and 0.5% Halad-22A.

Cement should be mixed at 82.2#/cu ft (11 ppg). Slurry yield is 3.21 cu ft/sack.

Mixing water requirements are 1.50 cu ft/sack (11.22 gal/sack).

9-5/8" LINER RUNNING PROCEDURE

The drilling program for Well KA2-1 has been written in such a way as to handle all situations that occur during the drilling. Due to the remote location and shipping requirements we must consider all possible hole conditions. These conditions that should be anticipated are listed in order of increasing severity as follows:

1. The 12-1/4" hole is drilled with little or no loss circulation encountered. Due to lost circulation encountered in drilling it would be highly probable that loss of circulation may occur during the cementing of the 9-5/8" liner.
   In this situation where lost circulation has not presented a significant problem during drilling, I feel that a conventional method should be employed in the running and cementing procedure for the 9-5/8" liner. The attached program "PROCEDURE FOR RUNNING AND CEMENTING 9-5/8" LINER WITHOUT EXTERNAL CASING PACKER AND MULTI-STAGE CEMENTER" should be used.

2. The 12-1/4" hole is drilled with air, aerated water or mud, with moderate loss circulation, that is loss circulation encountered in several zones which could be sealed with cement or LCM, or partial loss circulation zones which may take fluid periodically during drilling operations. Probability of lost circulation during cementing is high and should be anticipated.
   In this situation a certain amount of caution should be used in running and cementing the 9-5/8" liner to insure a competent cement job. A 9-5/8" liner utilizing a multi-stage cement collar strategically located could assist in obtaining an adequate cement job. The attached program "PROCEDURE FOR RUNNING AND CEMENTING 9-5/8" LINER WITH MULTI-STAGE CEMENTER" should be used.

3. The 12-1/4" hole is drilled using air or aerated water because of complete loss of circulation during the drilling. Sealing of these loss circulation zones prove to be unsuccessful or extensive causing a great loss of time therefore air or aerated fluid is used to drill the well. Probability of loss circulation during the cement job is high, therefore extreme methods of cementing the liner should be used.
   In this situation where major problems exist in the well, extreme procedures and technologies should be employed to insure an adequate cement job. The attached program "PROCEDURE FOR RUNNING AND CEMENTING 9-5/8" LINER EQUIPPED WITH EXTERNAL CASING PACKER AND HYDRAULIC CEMENTER" should be used.

PROCEDURE FOR RUNNING AND CEMENTING 9-5/8" LINER
WITHOUT EXTERNAL CASING PACKER AND MULTI-STAGE CEMENTER

1. Drill to casing depth at approximately 6000-7000′ dependent on temperature and geology.

2. Circulate for 2-3 hours to clean and cool hole.

3. Pull out of hole.

4. Rig up and run logs as indicated by geologic staff. Wait on bottom with temperature log for 30 minutes before pulling out of hole.

5. Rig down loggers and run in hole with bit and monel to total depth.

6. Circulate for 2 hours and make short trip. Circulate for 1-2 hours after short trip.

7. Pull out of hole and rig up to run 9-5/8" liner. Run additional directional surveys while pulling out of hole if necessary.

8. Run 9-5/8" liner grades, weights and thread design as indicated in detail sheet with float shoe on bottom and float collar two joints up. Centralizers should be located one in the middle of the bottom two joints and then one every to every other collar upward to within 60′ of the hanger. Use T-Bar rigid centralizers totally in bottom portion of the string and then as required in the upper portion. Run casing adjusters at 600′, 1800′ and 3400′ above shoe joint if required.

9. Circulate two full circulations to clean up and cool down well prior to cementing.

   Note: If casing can still be moved after running to bottom then move casing throughout circulation and cementing job and hang after cement is in place. If casing will not move after running to bottom, then hang liner before circulating and cementing job.

10. If loss circulation is encountered, pump 20 BBls of CaCl2 water and 10 BBls of fresh water ahead of 20 BBls of sodium silicate.

11. Pump in 20 BBls of viscous Geo-Gel mud preflush.

12. Pump cement without any water spacers. Pump stage 1: Class G cement and perlite blended at a ratio of 1:1 with 40% silica flour, 3% gel and friction reducer. Retard to give 2-3 hours

pumping time at 350 degrees F. Use 100% excess. If lost circulation is a problem, cement may be required to be changed to a spherelite blend. See note at bottom of this procedure. Pump stage 1 as per precalculated volumes.

13. Pump stage 2: Class G cement blended with 40% silica flour, 3% gel and friction reducer. Retard to give 2-3 hours pumping time at 350 degrees F. Pump 200 cu ft of this stage 2 cement. The last 100 cu ft should be staged in: Pump 35 cu ft and shut down for 5-10 minutes, then pump 35 cu ft and shut down again for 5-10 minutes before pumping the last 30 cu ft.

14. Once all cement has been pumped then rig down circulating equipment, hang liner and pull out of liner hanger with drill pipe and pull up 90' and circulate out excess cement on top of liner top.

15. Wait on cement 12 hours. Run in hole with 12-1/4" bit to top of cement, drill out cement to liner top. Wait a full 24 hours from the time cement was in place or until samples have set before pressure testing lap to 1000 psi surface pressure. Squeeze lap if necessary to obtain a pressure test.

16. Trip to change bits to 8-1/2" and clean out cement from inside of the 9-5/8" liner top.

17. Retest liner lap to 1000 psi surface pressure. Squeeze if necessary to obtain a pressure test.

18. Drill out cement, float collar and float shoe with 8-1/2" bit. Drill 60' of formation with mud.

19. Circulate to clean hole and then displace mud in hole for water.

20. Trip out of hole to pick up stabilization.

21. Run back in hole and aerate water. Drill ahead with aerated water to commercial production or total depth.

NOTE: Spherelite cement should be blended as follows:

Class G cement blended with 40% silica flour, 50 lbs per sack of cement of spherelite, 4% gel, 1.25% friction reducer and fluid loss agent.

Cement should be mixed at 88.3 lbs per cu ft (11.8 ppg). Slurry yield is 3.16 cu ft per sack of cement.

Mixing water requirements are 1.5 cu ft per sack (11.22 gal/sack).

9-5/8" CASING PROPERTIES

L-80, 47 ppf, Buttress, Burst: 6870 psi, Collapse: 4760 psi,
Tension: 1,122,000 lbs.

L-80, 53.5 ppf, Buttress, Burst: 6330 psi, Collapse: 3810 psi
Tension: 1,038,000 lbs.

L-80, 40 ppf, Buttress, Burst: 5750 psi, Collapse: 3090 psi,
Tension: 947,000 lbs.

PROCEDURE FOR RUNNING AND CEMENTING 9-5/8" LINER WITH MULTI-STAGE CEMENTER

1. Drill to casing depth at approximately 6000 - 8000' dependent on temperature and geology.

2. Circulate for 2-3 hours to clean and cool hole.

3. Pull out of hole.

4. Rig up and run logs as indicated by geologic staff. Wait on bottom with temperature log for 30 minutes before pulling out of hole.

5. Rig down loggers and run in hole with bit and monel to total depth.

6. Circulate for 2 hours and make short trip. Circulate for 1-2 hours after short trip.

7. Pull out of hole and rig up to run 9-5/8" liner. Run additional directional surveys while pulling out of hole if necessary.

8. Run 9-5/8" liner grades, weights and thread design as indicated in detail sheet with float shoe on bottom and float collar two joints up. Centralizers should be located one in the middle of the bottom two joints and then one every to every other collar upward to within 60' of the hanger. Install multi-stage cementer in a strategic location in the liner string. The location of the multi-stage cementer should be such that the bottom portion can be cemented successfully without loss circulation. The upper portion can then be cemented after the bottom has had time to set without any loss circulation during cementing. A probable location is just above the loss circulation zones. If the hole was air drilled a good location would be approximately 1200' above the casing shoe. Use 12" T-bar rigid centralizers totally in the bottom portion of the string and then as required in the upper portion. Run casing adjusters at 600', 1800', and 3400' above shoe joint as required.

9. Circulate two full circulations to clean up and cool down well prior to cementing.

   Note: If casing can still be moved after running to bottom then move casing throughout circulation and cementing job and hang after stage 1 cement is in place. If casing will not move after running to bottom, then hang liner before circulating and cementing job.

10. If loss circulation is a problem then pump 20 BBls of CaCl2 water and 10 BBls of fresh water ahead of 20 BBls of sodium

silicate.

11. Pump in 20 BBls of viscous Geo-Gel mud preflush.

12. Pump cement without any water spacers. Pump stage 1: Class G cement and perlite blended at a ratio of 1:1 with 40% silica flour, 3% gel and friction reducer. Retard to give 4-5 hours pumping time at 350 degrees F. Pump in calculated volume to fill the annulus of the 12-1/4" hole x 9-5/8" liner from the liner shoe to the stage collar with 100% excess, with approximately 200 cu ft of tail cement consisting of Class G cement blended with 40% silica flour, 3% gel and friction reducer. If loss circulation is a problem, cement may be changed to a spherelite blend. See note at the bottom of this procedure.

13. Pump stage 1 cement and drop dart for wiper plug. Displace cement with water. Bump plug and open multi-stage cementer.

14. After the stage collar has been opened then circulate out excess cement. Circulate and cool hole for 2 hours prior to pumping stage 2 cement. Hang liner at this point.

15. Pump in 20 BBls of CaCl2 water and 10 BBls of fresh water ahead of 20 BBls of sodium silicate.

16. Pump in 220 BBls of viscous Geo-Gel mud preflush.

17. Pump in stage 2 cement without any water spacers. Pump Class G cement and perlite blended at a ratio of 1:1 with 40% silica flour, 3% gel and friction reducer. Retard to give 2-3 hours pumping time at 350 degress F. Pump in calculated volume of cement to fill 12-1/4" hole x 9-5/8" liner to lap area without excess. Calculated volume should include a 200 cu ft tail slurry of Class G cement blended with 40% silica flour, 3% gel and friction reducer. Retard to give 2-3 hours of pumping time at 350 degrees F. Displace cement with water.

18. Once all cement has been pumped then rig down circulating equipment and pull out of liner hanger with drill pipe and pull up 90' and circulate out excess cement on top of liner top.

19. Wait on cement 12 hours. Run in hole with 12-1/4" bit to top of cement, drill out cement to liner top. Wait a full 24 hours from the time cement was in place or until samples have set before pressure testing lap to 1000 psi surface pressure. Squeeze lap if necessary to obtain a pressure test.

20. Trip to change bits to 8-1/2" and clean out cement from inside of 9-5/8" liner top.

21. Retest liner lap to 1000 psi surface pressure. Squeeze if necessary to obtain a pressure test.

22. Drill out cement, float collar and float shoe with 8-1/2" bit. Drill 60' of formation with mud or water.

23. Circulate to clean hole and then displace mud in hole for water if necessary.

24. Trip out of hole to pick up stabilization.

25. Run back in hole and aerate water. Drill ahead with aerated water to commercial production or total depth.

NOTE: Spherelite cement should be blended as follows:

Class G cement blended with 40% silica flour, 50 lbs per sack of cement of spherelite, 4% gel, 1.25% friction reducer and fluid loss agent.

Cement should be mixed at 88.3 lbs per sack of cement. Slurry yield is 3.16 cu ft per sack of cement.

Mixing water requirements are 1.5 cu ft per sack (11.22 gal/sack).

9-5/8" CASING PROPERTIES

L-80, 47 ppf, Buttress, Burst: 6870 psi, Collapse: 4760 psi, Tension: 1,122,000 lbs.

L-80, 43.5 ppf, Buttress, Burst 6330 psi, Collapse: 3810 psi, Tension: 1,038,000 lbs.

L-80, 40 ppf, Buttress, Burst: 5750 psi, Collapse: 3090 psi, Tension: 947,000 lbs.

PROCEDURE FOR RUNNING AND CEMENTING 9-5/8" LINER
EQUIPPED WITH EXTERNAL CASING PACKER AND HYDRAULIC CEMENTER

1. Drill to casing depth at approximately 6000 - 8000′ dependent on temperature and geology.

2. Circulate for 2-3 hours.

3. Pull out of hole.

4. Rig up and run logs as indicated by geologic staff. Wait on bottom with temperature log for 30 minutes before pulling out of hole.

5. Rig down loggers and run in hole with bit and monel to total depth.

6. Circulate for 2 hours and short trip. Circulate for 1-2 hours after short trip.

7. Pull out of hole and rig up to run 9-5/8" liner. Run additional directional surveys while pulling out of hole if necessary.

8. Run 9-5/8" liner grades, weights and thread design as indicated in attached detail sheet with float shoe on bottom and float collar two joints up. Centralizers should be located one in the middle of bottom two joints and then one every other collar upward to within 60′ of hanger. Use T-Bar rigid centralizers in the bottom portion of the string and then as required in the upper portion. If lost circulation is a problem or the hole has been drilled with air or aerated water then CTC external casing packer should be positioned in string 200-300′ from bottom with Halliburton hydraulic stage cementer located above packer. Run casing adjuster at 600′, 1800′, and 3400′ from shoe joint as required. A T-Bar centralizer should be located above and below packer.

9. Run liner equipment. See attached Pre-Job Recommendations.

   Check all equipment to be run on 9-5/8" liner.
   a. Use Instructions & Operations Sheet TE 7.00381. Measure all parts OD and ID.
   b. Check threads on all tools.
   c. Midway liner hanger running tool. Stinger must be reduced down to 3" OD 2.75 ID and run 10-12.5" below bottom of liner hanger as shown on print TE 7.00378. This is when the liner hanger string is at the bottom of its travel.
   d. Part numbers are given on print TE 7.00377 for tools. ID and OD for SR Plug set is given on print TE 7.00379 OD and OD for HOS Cementer are given on print TE 7.00380.

e. All parts and number should check with prints.
f. HOS Tool has four shear pins that will take 2880 psi over Hydrostatic pressure to open it, two other pins are with the tool. Each pin adds 712.5 psi pressure to shear. Open pressure may be adjusted as needed.

10. Installing equipment onto casing strings. See attached Recommendations During Job for further details.

a. Guide shoe.
b. Centralizers on two joints.
c. Float collar.
d. Centralizers as per program.
e. Casing.
f. CTC Packers 200' off bottom.
g. One joint with centralizer in middle.
h. HOS Cementer.
i. Centralizers as per program - run casing adjusters located 1500' and 3000' from shoe.
j. Casing to top of liner. Fill liner as going in hole.
k. Make up SR Baffle Collar on bottom of liner hanger.*
l. Take O-ring off SR plug set and put on SR Baffle Collar.
m. Make up SR plug set on Baffle Collar and tighten at plug set to Baffle Collar. Be sure all parts are tight.
n. Circulate the liner at 3-4 BPM. Stop and circulate 2-3 times while running in hole with liner assembly on drill pipe.

*Be sure there are no areas of drill pipe on liner hanger less than 2.75 ID.

11. Cement liner in three stages.

a. Calculate volume of cement for bottom stage. (200 ft of 12-1/4" hole and 9-5/8" annulus plus shoe joint volume and volume to inflate CTC Packer).
b. Mix cement for above.
c. Pump cement for 200' annulus and shoe joint. Release first stage dart 809.81266 and pump cement for inflated CTC. (Cement to inflate packer should be Class G with 40% silica flour and friction reducer, no perlite.)
d. Pump 10 BBls spacer then displace with mud at 3-4 BPM until 10 BBls before dart should land in SR lower plug - slow rate to 2 BPM. Pressure should go to 1800 psi and plug release.
e. Displace shut off plug at 5-6 BPM until 30 BBls before plug lands. Then pump at 1-2 BPM.

f. When shut off plug lands in shut off baffle, pressure up to 500 psi and shut down.

12. Inflate CTC Packer with cement. See attached Recommendations During Inflation Sequence for further details.

    a. Check volume of displacement tank.
    b. Increase pressure slowly to 700 psi and shut down.
    c. Increase pressure slowly to 800 psi.
    d. Increase pressure slowly to 900 psi or until tool opens.
    e. Pump in 2-5 cu ft of cement per stage until CTC packer is inflated.
    f. Increase pressure to 1000 psi to close CTC packer.
    g. With pressure at 500 psi, check volume of cement needed to inflate tools.
    h. Pressure up to 2800 psi and open HOS.
    i. Circulate well as needed.
    j. Cement liner as per program. Pump spacer. Pump cement.
    k. Release dart for shut off plug. Pump at 4-5 BPM. Pump 10 BBls spacer - then mud.
    l. Displace to within 10 BBls of plug, slow to 2 BPM.
    m. Pressure to 1950-2000 psi to release plug.
    n. Displace at 4-5 BPM.
    o. When plug lands in HOS, pressure up to 3000 psi to close tool. You may have to go to 3500 psi. Hold pressure for 2 minutes.
    p. Release pressure if holding; back off liner hanger tool.
    q. Come out of hole with tools.
    r. Wait 24 hrs and drill out.

13. Rig down circulating equipment, pull out of hanger with drill pipe and pull up 90' and circulate out excess cement leaving 90 linear ft of cement on top of liner top.

14. Wait on cement for 12 hrs. Run in hole with 12-1/4" bit to top of liner and circulate to clean out excess cement. Wait 24 hrs from the time cement was in place and pressure test lap to 1000 psi. Squeeze if necessary.

15. Trip to change bits to 8-1/2" and clean out cement from inside the 9-5/8" liner top.

16. Retest liner lap to 1000 psi surface pressure. Squeeze if necessary.

17. Drill out cement, float collar and float shoe with 8-1/2" bit. Drill 30' of formation.

18. Circulate and change out mud system for water.

19. Trip to pick up stabilization.

NOTE: Spherelite cement should be blended as follows:

Class G cement blended with 40% silica flour, 50 lbs per sack of cement of spherelite, 4% gel, 1.25% CFR-2, and 0.5% Halad-22A.

Cement should be mixed at 88.3lbs/cu ft (11.8 ppg). Slurry yield is 3.16 cu ft/sack.

Mixing water requirements are 1.50 cu ft/sack (11.22 gal/sack).

CASING PROPERTIES

L-80, 47ppf, Buttress, Burst: 6870 psi, Collapse: 4760 psi, Tension: 1,122,000 lbs.

L-80, 43.5ppf, Buttress, Burst: 7930 psi, Collapse: 6620 psi, Tension: 1,286,000 lbs.

L-80, 40 ppf, Buttress, Burst: 5750 psi, Collapse: 3090 psi, Tension: 947,000 lbs.

PRE-JOB RECOMMENDATIONS

1. In close clearance (1/2"-1") installations:

    a. Run a casing scraper.
    b. Drill open hole section with a stabilized packed hole assembly if possible.

2. In liner installations, notify CTC of type of liner equipment before packers are shipped.

3. Insure that everyone involved understands the Payzone Packer system and specific duties they are to perform.

4. Obtain all pertinent well data, including:

    a. Minimum wellbore restriction (should be 1/2" greater than packer OD).
    b. If casing damage is suspected, run a microscopic caliper and/or casing scraper.
    c. Calipered hole size in zone of interest should not exceed maximum recommended hole size. Use "Hole Size vs. Recommended Inflation Pressure Chart" to set pressure control valve.
    d. If junk has been lost in hole it should be fished or driven to below Payzone setting depth.
    e. Clients maximum allowable surface pressure (burst strength of casing with a safety factor), should be obtained prior to setting shear pin.
    f. If hole size adjacent to end assemblies is more than 1" larger than packer OD run one centralizer above and below each packer.

5. Inspect auxiliary equipment.

    a. Float shoe.
    b. Float collar.
    c. Bottom cement wiper plug (proper size, rupture diaphragm).
    d. Two top cement wiper plugs (proper size, no rupture diaphragm).
    e. Pressure recorder (5000 psi scale if possible).
    f. Chicksan lines.
    g. Cementing head.
    h. Verify that adequate inflation cement is available.
    i. Obtain a dry sample of all cements used on the job.

6. Review primary cementing plans and calculate theoretical bottom hole pressure during cementing operations. If expected pressures approach fracture gradient, pressure anomalies are probable and bottom wiper plug should not be run so that knockoff rod protection stays intact.

7. Calculate displacement volumes. Know at what displacement the following events should take place:

    a. Bottom wiper passes packers (knockoff rods).
    b. Bottom wiper lands in float collar.
    c. First top wiper passes packer.
    d. First top wiper lands in float collar, and
    e. Top of inflation cement (second top wiper plug) relative to upper packer.

8. Total inflation pressure is critical to Payzone Packer performance. Before starting a job know and/or calculate: 1. hydrostatic pressure inside and outside the casing at packer setting depth, 2. pore pressure, 3. fracture pressure, 4. maximum recommended differential inflation pressure from hole size vs pressure chart, 5. resultant effective stress.

    a. Total inflation pressure equals:
        1. Hydrostatic pressure inside casing (packer depth) + Applied surface pressure

        OR

        2. Hydrostatic pressure outside casing (packer depth) + Differential inflation pressure

    b. Differential inflation pressure equals:
        1. Total inflation pressure minus Pressure outside casing (packer depth)

        OR

        2. Applied surface pressure minus Balance pressure

    c. Balance pressure equals:
        1. Surface pressure required to offset "U" tube pressure
        2. Approximated by surface pressure (pumping at 1/4-1/2 BBl/min) just prior to plug bump.

    d. Radial effective stress (Seal Load, Wellbore Support) equals:
        Total inflation pressure minus pore pressure.
        -In all cases the differential inflation pressure must be within the hole size vs differential pressure capabilities of the equipment.
        -For zone isolation the radial effective stress (seal load) should be at least 500 psi and total inflation pressure must be less than fracture pressure.

9. Review casing tally. Re-tally casing during run-in if necessary. This is critical if positioning log is not to be run.

10. Make up casing according to API specifications with proper torque and API pipe dope.

Note: It is extremely difficult to properly inflate packers with a casing leak.

11. Epoxy thread lock should be used on packer/casing connections, float collar, and float shoe.

12. A minimum number of only high quality (API approved) centralizers be run below packer(s). If pipe is to be reciprocated, and hole size adjacent to end assemblies does not exceed packer OD plus 2", spacing between packers and centralizers should be greater than reciprocation stroke. Do not place scratchers in this area.

13. If positioning is critical, packers should be logged into position.

14. Insure that cement has adequate pump time.

15. Inflation cement should have an API water loss of less than 150 cc. Inflation cement must not contain lost circulation material.

RECOMMENDATIONS DURING JOB

1. Verify that external cementing aids (centralizers, scratchers, etc.) are properly installed.

2. Run-in speed 1 ft/sec (may be prudently increased to 2 ft/sec per Steps 3 and 4 below).

3. Monitor returns, if more than 30' of casing is run before receiving full returns - SLOW DOWN.

4. Monitor weight indicator - excessive weight loss during run indicates that run-in speed may be too fast.

5. Pressure test lines before beginning cement job. Repair all leaks no matter how small.

6. Verify that wiper plugs are dropped at proper time in proper sequence.

7. Monitor returns during entire job.

8. Monitor mixing and pumping of inflation cement. Verify volume and weight of inflation cement. Batch mix if possible.

   Note: If inflation cement is not batch mixed, monitor BBl counter, but do not rely on its accuracy. Insist that mix water be accurately measured from tanks and that cement density remains constant and proper. (If cement is mixed at proper weight, mix water volume is an accurate indicator of cement volume.)

9. Insist that plug drop be verified via tattle-tale, flag or radioactive techniques.

10. Monitor displacement volume, pump rate and surface pressure during entire displacement process.

11. Determine balance pressure during last 5 BBl of displacement. (Slow displacement to 1/4-1/2 BBl/min and record pressure.)

12. Required displacement volume will normally exceed theoretical casing volume. If mud is used for displacement, expect up to 6%.

RECOMMENDATIONS DURING INFLATION SEQUENCE

1. When first plug lands in float collar:

2. Open shear valve in first or bottom packer by rapidly applying appropriate surface pressure, i.e. balance pressure plus pressure rating of shear valve. (Monitor volume displaced.) Stop pumps and monitor pressure decline, increase pressure by 200 psi or as needed to open valve. Record volume in displacement tanks.

   NOTES:

   a. Flow rate into Payzone packers is relatively slow (1/4 BBl/min). Therefore, it is generally impractical and not advisable to pump continuously during inflation. The preferred procedure is to rapidly increase surface pressure, stop pumping and monitor pressure decline. When the packer is full, the pressure decline will stop.

   b. The expected pressure response during inflation is a function of several variables. In general the following reduce the distinctiveness of the pressure response.
      1. Increased well depth.
      2. Compressability and volume of fluid within the casing string.
      3. Large diameter casing.
      4. Viscosity of inflation cement.
      5. Small inflation volume.

      For example, the pressure response during inflation of a 9-5/8" packer at 12,000' with 3/4 BBl of 16.4 lbs/gal cement may be non-distinct while inflation of a 5-1/2" packer with 1 BBl at 6000' would be very distinct.

3. When packer is completely inflated (surface pressure remains constant), apply final desired inflation pressure.

   a. Record volume pumped and hold pressure for 5-10 min.

   b. Bleed surface pressure slowly back to balance pressure (and/or point 1a above and record flowback volume.

   c. Release pressure slowly.

Note: In shallow (less than 7000') unconsolidated sands, the hole size often enlarges as the packer re-stresses the sand. In these installations, final inflation pressure should be adjusted or reduced in accordance with hole size.

This may be done by converting inflation volume to equivalent hole diameter and using "Hole Size vs Recommended Inflation Pressure Chart".

THINGS TO AVOID

1. Avoid using bottom wiper plugs whenever possible. This is critical if bottomhole pressures during the cement operation are likely to exceed frac pressure.

2. Avoid using spacer fluids below inflation cement because volumetric error and/or pressure anomalies may result in mud-filled packers.

   Note: The use of lightweight spacer fluids below the inflation cement imposes a hydrostatic differential pressure across the valve collar equal to [Weight of cement in annulus (lbs/gal) minus weight of spacer fluid below packer (lbs/gal)] multiplied by .052 times height of spacer fluid below packer.

3. Do not exceed fracture pressure in isolation installations.

4. If spacer fluids are used as substitues for wiper plugs above inflation cement, increase cement volume to compensate for contamination of the upper 100′ of inflation cement.

5. Do not use differential fill equipment because debris may enter casing. Some varieties of differential fill equipment must be opened via applied casing pressure prior to circulation. This is not compatible with our valve system.

6. Insist that liner hanger packoffs not be set prior to packer inflation.

7. Do not spud casing - circulate through bridges.

8. Do not use cement with more than 6% Plaster of Paris or Calseal cement.

9. Do not use loss circulation material in inflation cement.

PROCEDURE FOR RUNNING 9-5/8" TIE-BACK CASING
OPTIONAL

1. Kill well with cold water. Pick up Halliburton 9-5/8" EZSV cement retainer on drill pipe and run in hole to 300' below liner top. Set EZSV at this point.

2. Spot a 50 linear foot thick viscous gel pill on top of EZSV and 50 linear feet of cement on top of gel. Fill hole with water and circulate to cool and clean hole. Make appropriate changes to wellhead assembly.

3. Run 9-5/8" casing scraper to clean out liner tie-back sleeve.

4. Rig up and run 9-5/8" tie-back string to top of liner with float collar 40' (1 joint) above stab-in tool on bottom. Stab-in tool will be equipped with slip. Stab into liner, engage slips on the 13-3/8" and pull up on tie-back to 200,000 lbs to pretension tie-back.

5. Cement tie-back as per attached cementing program. Bring cement back to surface between 9-5/8" and 13-3/8" casing, setting centralizer in 13-3/8" casing head before cementing.

6. Wait on cement 12 hours, then release tension.

7. Land 9-5/8" casing. Pick up 12" blow out preventer stack and install expansion spool (12" 900 x 10" 900) equipped with two 3" flanged outlets with 3" 2000 psi wing valves. Install 10" 900 Master Valve and 10" 900 x 12" 1500 adaptor spool and reinstall blow out preventer stack.

8. Test blow out preventer stack, 10" master valve, expansion spool and 9-5/8" tie-back to 1500 psi.

9. Pick up 8-1/2" bit and drill out excess cement and float collar. Work bit through lap area and retest to 1000 psi. Squeeze if necessary.

10. Drill out cement and clean out gel to top of EZSV.

11. Trip for EZSV picking tool and remove EZSV.

12. Return well to production and retest if necessary, using air to induce well to flow.

13. Lay down drill pipe, remove blow out preventer equipment,and move rig off, releasing rig.

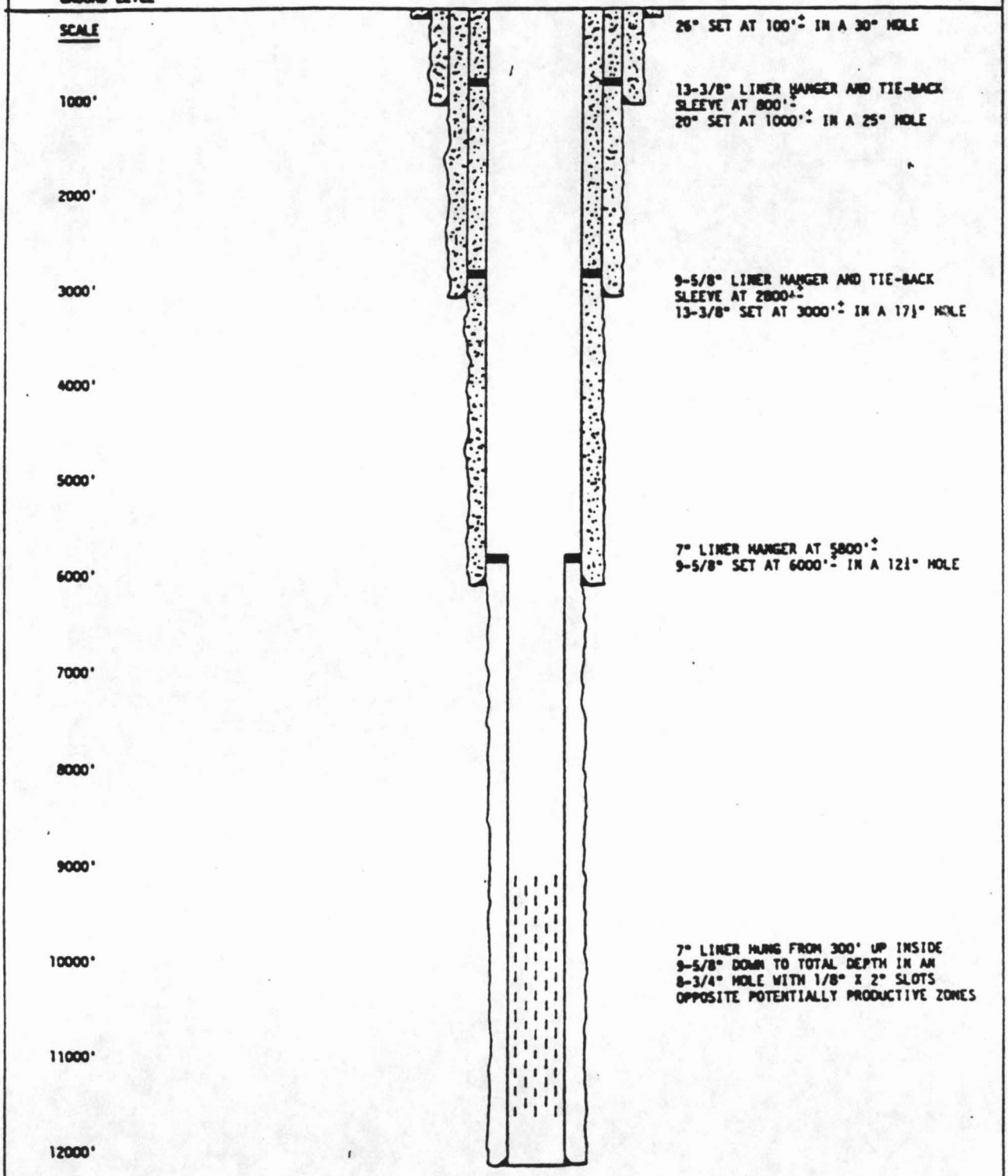
14. Prepare for long term test.

15. Test well.

9-5/8" CASING PROPERTIES

L-80, 40 ppf, Buttress, Burst: 5750 psi, Collapse: 3090 psi, Tension: 947,000 lbs.

FIGURES



REVISED	DATE

TSI ThermoSource Inc.

WELL COMPLETION DIAGRAM
TRUE GEOTHERMAL

DRAWN	
FOR:	TRUE
BY:	LEC
DATE:	8/15/87
SCALE:	1"=1000' Vert.
DRAWING No.	001

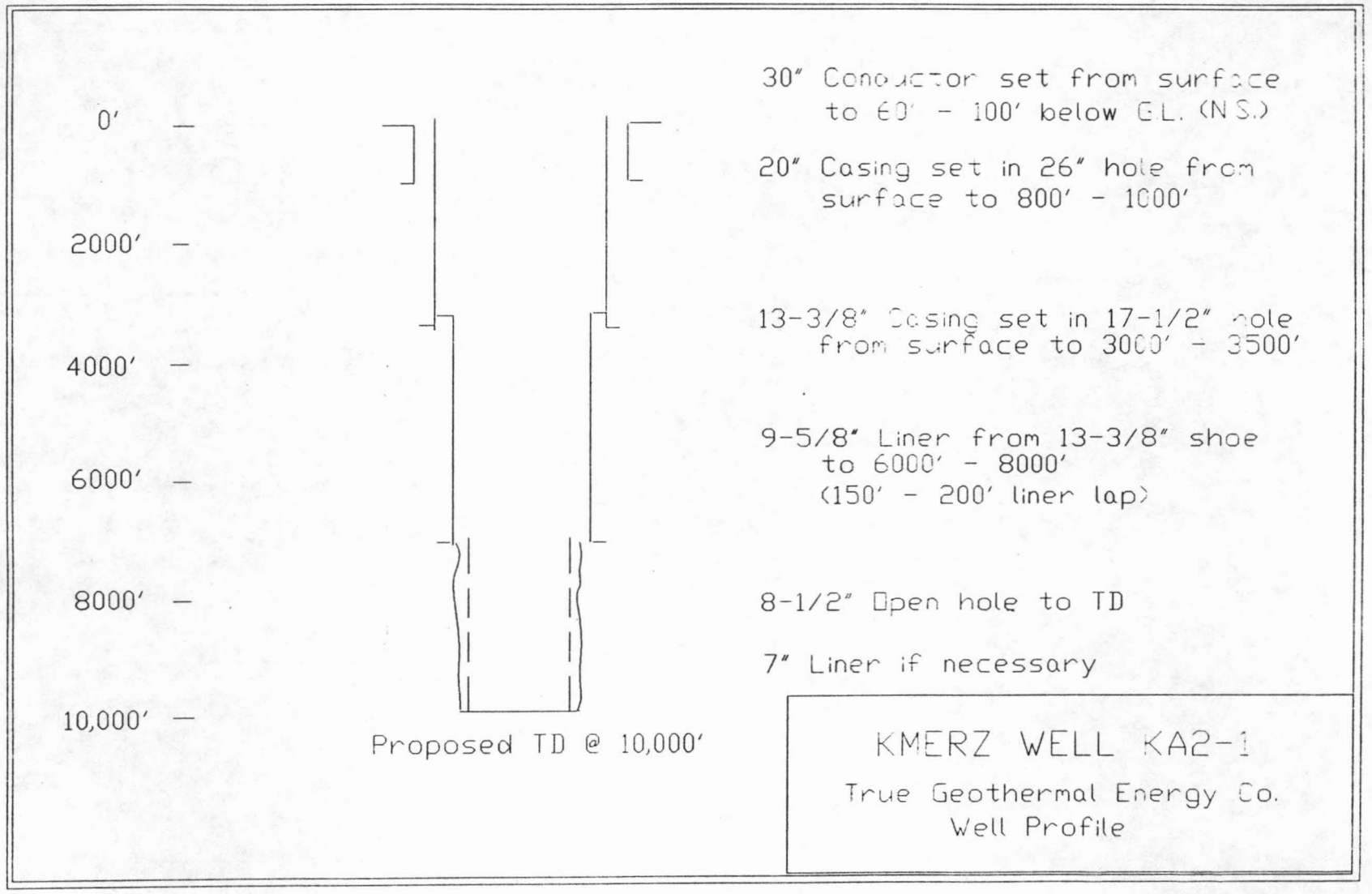

0'
2000'
4000'
6000'
8000'
10,000'
Proposed TD @ 10,000'
30" Conductor set from surface to 60' - 100' below G.L. (N.S.)
20" Casing set in 26" hole from surface to 800' - 1000'
13-3/8" Casing set in 17-1/2" hole from surface to 3000' - 3500'
9-5/8" Liner from 13-3/8" shoe to 6000' - 8000' (150' - 200' liner lap)
8-1/2" Open hole to TD
7" Liner if necessary
KMERZ WELL KA2-1
True Geothermal Energy Co.
Well Profile

FIGURE 001

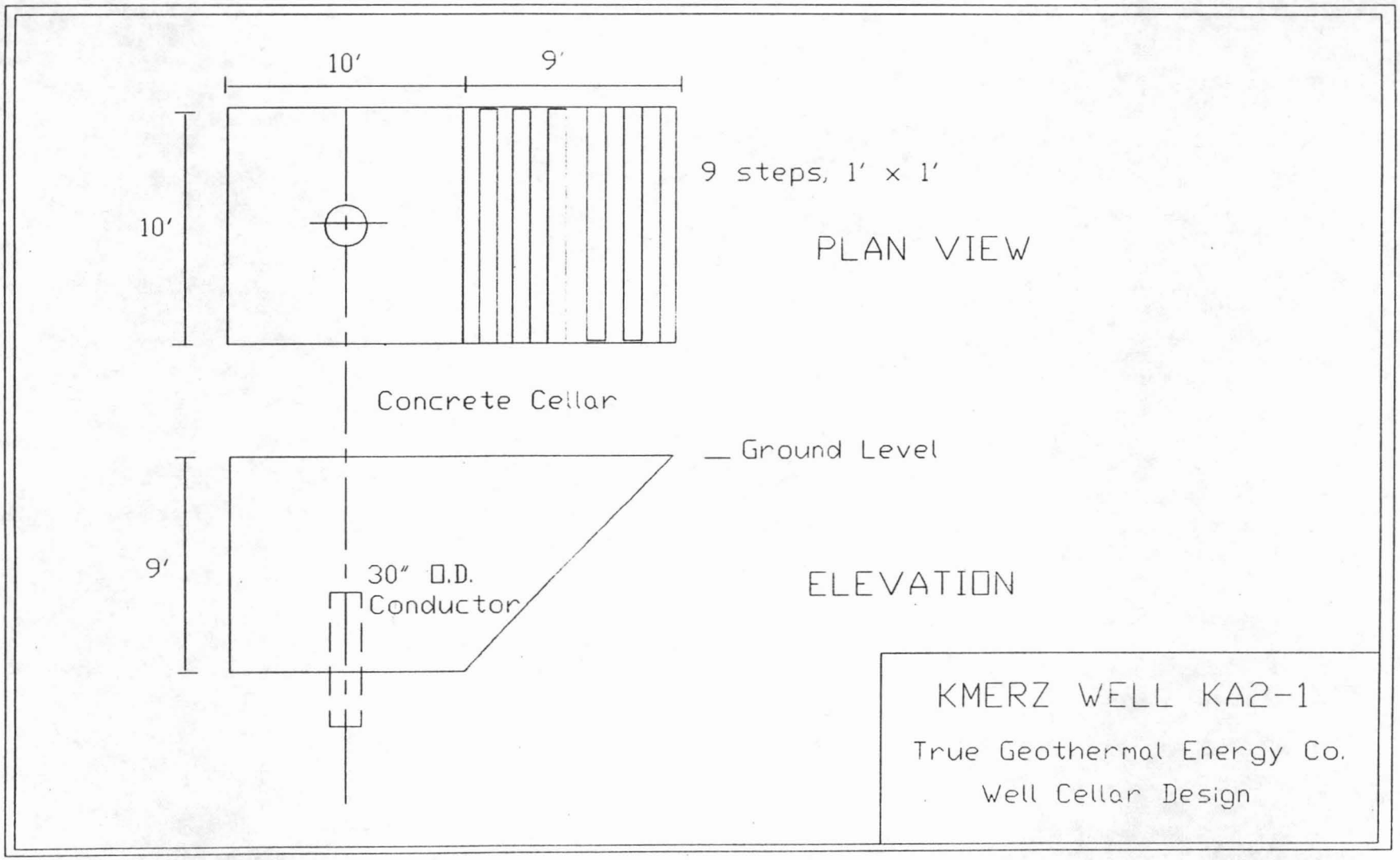

10'
9'
10'
9 steps, 1' x 1'
PLAN VIEW
Concrete Cellar
Ground Level
9'
30" O.D.
Conductor
ELEVATION
KMERZ WELL KA2-1
True Geothermal Energy Co.
Well Cellar Design

FIGURE 002

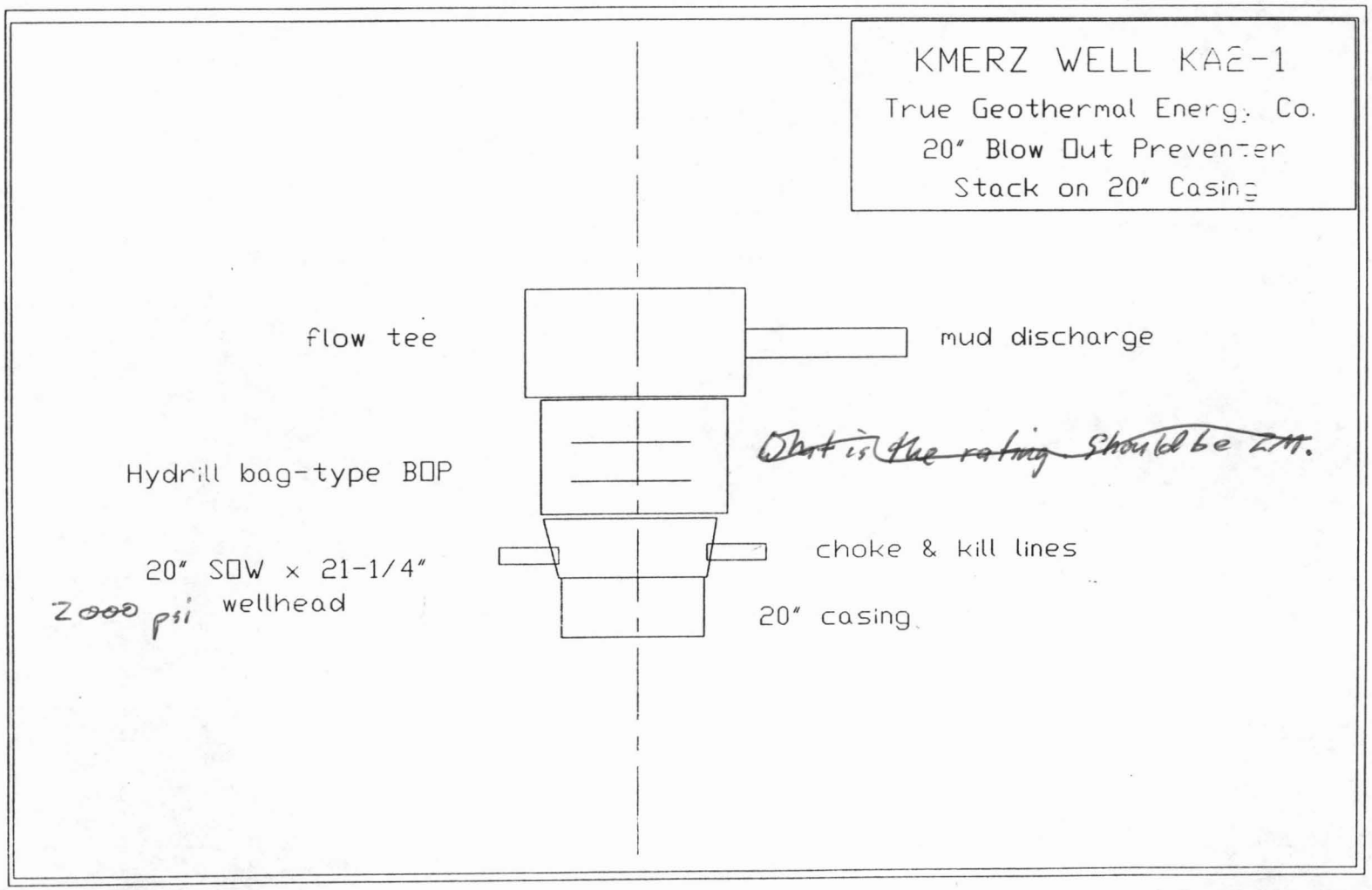

KMERZ WELL KAZ-1
True Geothermal Energy Co.
20" Blow Out Preventer
Stack on 20" Casing
flow tee
mud discharge
Hydrill bag-type BOP
What is the rating Should be 2M.
20" SOW x 21-1/4"
2000 psi wellhead
choke & kill lines
20" casing

FIGURE 003

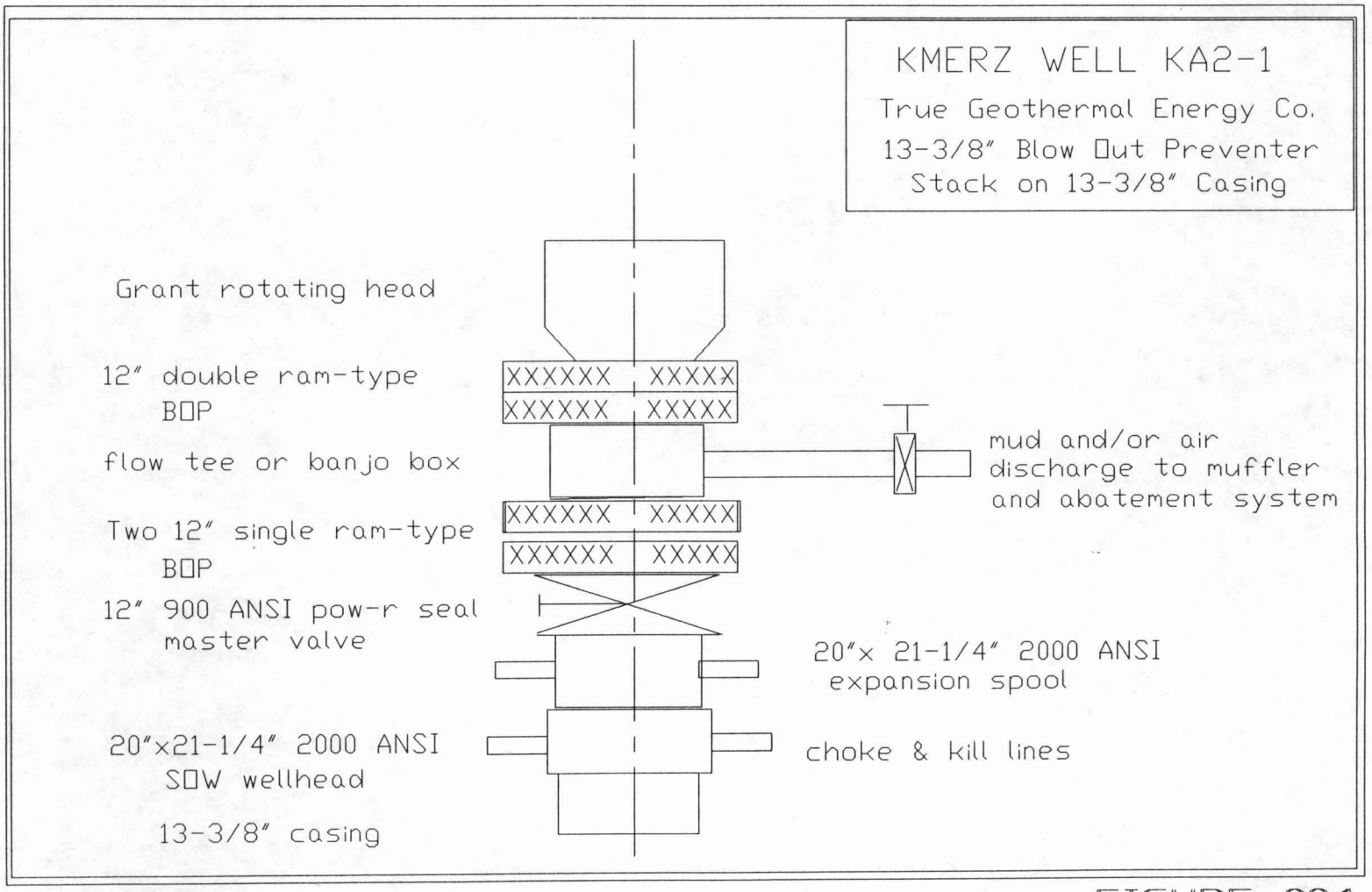

KMERZ WELL KA2-1
True Geothermal Energy Co.
13-3/8" Blow Out Preventer
Stack on 13-3/8" Casing
Grant rotating head
12" double ram-type
BOP
flow tee or banjo box
Two 12" single ram-type
BOP
12" 900 ANSI pow-r seal
master valve
20"x21-1/4" 2000 ANSI
SOW wellhead
13-3/8" casing
XXXXXX XXXXX
XXXXXX XXXXX
XXXXXX XXXXX
XXXXXX XXXXX
mud and/or air
discharge to muffler
and abatement system
20"x 21-1/4" 2000 ANSI
expansion spool
choke & kill lines

FIGURE 004

TABLES

ThermaSource Inc.
P.O. Box 1236 • Santa Rosa, CA 95402

CASING, CEMENTING AND BOP PROGRAMS

SIZE	DEPTH	WELL
20"	1000'	KA2-1

CASING PROGRAM

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS			
				TOP BURST	BOT. BURST	COLL.	TENSION
0-1000'	106.5	K-55	Buttress	3.31	9.21	1.64	9.99+
Casing Properties:							
Collapse-770 psi							
Burst-2320 psi							
Tension-1,683,000 lbs.							

DESIGN CONDITIONS

SURFACE BURST PRESSURE	- 2000	PSI	OUTSIDE MUD WT. (COLLAPSE) -	9.95	PPG
INSIDE MUD WEIGHT (BURST)	- 9.5	PPG	INSIDE MUD WT. (COLLAPSE) -	0	PPG
OUTSIDE MUD WEIGHT (BURST)	- 9.5	PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -	9.5	PPG
FRAC. GRAD. AT SHOE (BURST)	- 14.5	PPG	BIAXIAL LOAD: COLL. ☐ BURST ☐	BOUYANCY: YES ☐ NO ☒	

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

2690 cu ft (838 sx) of Class G cement blended with 50 lbs of spherelite per sack of cement, 40% silica flour, 4% gel, 5% hydrated lime, 1.25% CFR--2 and 0.5% Halad--22A tailed with 400 cu ft (252 sx) of Class G cement blended with 40% silica flour and 3% CaCl2

DESIRED TOP	EXCESS
Surface	100%

SLURRY VOL. - CU FT / (SLURRY NO.)	2690		400	
SLURRY YIELD - CUBIC FEET/SACK	3.21 cu ft/sx		1.59 cu ft/sx	
SLURRY DENSITY - PPG	82.2#/cu ft(11 ppg)		118#/cu ft(15.8 ppg)	
THICKENING TIME - DEPTH SCH/HRS, MIN.	2-3 hrs		2-3 hrs	
COMPRESSIVE STRENGTH - PSI/HOURS				

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Stab in float collar located 40' (1 joint) above float shoe on bottom.
2. Weld bottom of collars on bottom 4 joints.
3. Clean and Baker loc threads on float collar and shoe as well as bottom 4 joints.
4. Tac weld top of collars on bottom 2 joints.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. Run rigid centralizer in middle of bottom 2 joints, then one every other tool joint to within 100' of surface.
2. Use centralizer cement baskets as required due to lost circulation.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

1. Stab into float collar with drill pipe. Attempt to circulate with water.
2. Pump 200 cu ft CaCl2 water followed by 100 cu ft of fresh water, 200 cu ft Flo-chek, 200 cu ft Geo-gel, then cement slurries.

PRESSURE TESTING AND LANDING

1. Use 1" pipe in annulus of 20" AND 26" hole to bring cement back to surface if necessary.
2. Wait on cement 8 hours.

BOP PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI		
				RAM TYPE	ANNULAR TYPE	ROTATING HEAD
	2000	20"	See attached drawing	1500	1500	

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CASING, CEMENTING AND BOP PROGRAM

CASING PROGRAM

SIZE	DEPTH		WELL
13-3/8"	3500'	Full String	KA?-1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS			
				TOP BURST	BOT. BURST	COLL.	TENSION
0-3000'*	68	L-80	Buttress	2.03	1.95	1.51	6.44
3000-3500'**	72	L-80	Buttress	2.08	2.05	1.55	45.83
Casing Properties:*				Casing Propertires:**			
Collapse-2260 psi				Collapse-2670 psi			
Burst-5020 psi				Burst-5380 psi			
Tension-1,545,000 lbs				Tension-1,650,000 lbs			

DESIGN CONDITIONS

SURFACE BURST PRESSURE	- 3000	PSI	OUTSIDE MUD WT. (COLLAPSE) -	9.5	PPG
INSIDE MUD WEIGHT (BURST)	- 9.5	PPG	INSIDE MUD WT. (COLLAPSE) -	0	PPG
OUTSIDE MUD WEIGHT (BURST)	- 9.5	PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -	9.5	PPG
FRAC. GRAD. AT SHOE (BURST)	- 14.5	PPG	BIAXIAL LOAD: COLL. [X] BURST [X]	BOUYANCY: YES [ ] NO [X]	

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

4257 cu ft (1723 sx) Class G cemetn blended 1:1 with perlite and 40% silica flour, 4% gel and 0.65% CRF-2. Tailed with 300 cu ft (192 sx) of Class G cement blended with 40% silica flour and friction reducer. Both slurries to be blended with retardant to give 2-3 hours pumping time at reservoir temperature.

DESIRED TOP: Surface; EXCESS: 100%

SLURRY VOL. - CU FT / (SLURRY NO.)	4257		300	
SLURRY YIELD - CUBIC FEET/SACK	2.47		1.56	
SLURRY DENSITY - PPG	97.25#/cu ft(13.0 ppg)		118#/cu ft (15.8 ppg)	
THICKENING TIME - DEPTH SCH/HRS. MIN.	2-3 hrs		2-3 hrs	
COMPRESSIVE STRENGTH - PSI/HOURS				

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Run stab in float collar 40' (1 joint) above float shoe on bottom.
2. Weld bottom of collars on bottom 4 joints.
3. Clean and Baker loc threads on float collar and shoe as well as bottom 4 joints.
4. Tac-weld top of collars on bottom 2 joints.
5. Run 13-3/8" as full string or liner with tie-back as hole conditions dictate. See attached procedure.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. Run rigid centralizer in middle of bottom 8 joints. Then turbo-type centralizer on every other collar from bottom to within 200' of surface.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

1. If lost circulation is a problem run casing as directed in attached procedure. Use sodium silicate preflush as directoed.
2. Cement through drill pipe.
3. Pump cement of Stage 1 until cement appears at surface, then pump stage 2 cement.

PRESSURE TESTING AND LANDING

1. Wait on cement 12 hrs or until samples have set.
2. Cut & remove 20" casing. Install 12" x 20" expansion spool and blow out preventer stack as in attached drawing.

BOP PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI		
				RAM TYPE	ANNULAR TYPE	ROTATING HEA
	3000	12-3/8"	Rotating head & ram	1500	1500	1000

CASING, CEMENTING AND BOP PROGRAMS

CASING PROGRAM — SIZE: 13-3/8" | DEPTH: 3500'± | Liner | WELL: KA2-1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS			
				TOP BURST	BOT. BURST	COLL.	TENSION
900-3000'	68	L-80	Buttress	2.01	1.95	1.49	8.68
3000-3500'	72	L-80	Buttress	2.07	2.05	1.53	45.83

DESIGN CONDITIONS

SURFACE BURST PRESSURE	- 3000	PSI	OUTSIDE MUD WT. (COLLAPSE) -	9.5	PPG
INSIDE MUD WEIGHT (BURST)	- 9.5	PPG	INSIDE MUD WT. (COLLAPSE) -	0	PPG
OUTSIDE MUD WEIGHT (BURST)	- 9.5	PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -	9.5	PPG
FRAC. GRAD. AT SHOE (BURST)	- 14.5	PPG	BIAXIAL LOAD: COLL. [X] BURST [X]	BOUYANCY: YES [ ] NO [X]	

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

3340 cu ft (1041 sx) Class G cement blended with 50# per sack of cement of spherelite, 40% silica flour, 5% hydrated lime, 4% gel, 1.25% CFR-2, and 0.5% Halad-22A, tailed with 300 cu ft (189 sx) of Class G cement blended with 40% silica flour and friction reducer. Both slurries retarded to give 2-3 hrs pumping time at reservoir temperature. DESIRED TOP: 900'± | EXCESS: 100%

SLURRY VOL. - CU FT / (SLURRY NO.)	3340	300		
SLURRY YIELD - CUBIC FEET/SACK	3.21	1.59		
SLURRY DENSITY - PPG	82.2	118		
THICKENING TIME - DEPTH SCH/HRS, MIN.	2-3 hrs	2-3 hrs		
COMPRESSIVE STRENGTH - PSI/HOURS				

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Run float collar 40' above float shoe.
2. Weld bottom of collars on bottom 4 joints.
3. Clean and Baker loc threads on bottom 4 joints.
4. Tac-weld top of collars on last 2 joints.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. Hang liner 100' up inside 20" casing on drill pipe.
2. Run rigid centralizer cement baskets in middle of bottom 2 joints and one 10' up inside 20" casing and one just below stage collar if a stage is indicated.
3. Run centralizers every other tool joint to bottome of 20" casing.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

1. Attempt to circulate with water.
2. Pump 20 cu ft CaCl2 water and 100 cu ft water, followed by 200 cu ft Flo-Chek the 200 cu ft of Geo-gel, then cement slurries.
3. See attached program for more detail.

PRESSURE TESTING AND LANDING

1. Wait on cement 8 hrs. Clean out cement from top of 13-3/8" liner. Test lap to 1000 psi. Squeeze lap if necessary. Clean out and retest until a test is obtaned.

BOP PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI		
				RAM TYPE	ANNULAR TYPE	ROTATING HEAD
		No change until tie-back run				

CASING, CEMENTING AND BOP PROGRAMS

CASING PROGRAM

SIZE	DEPTH		WELL
13-3/8"	900'±	Tie-Back	KA2-1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS			
				TOP BURST	BOT. BURST	COLL.	TENSION
0-900'	68	K-55	Buttress	1.76	1.67	5.04	25.25

DESIGN CONDITIONS

SURFACE BURST PRESSURE	-	3000 PSI	OUTSIDE MUD WT. (COLLAPSE) -	9.5	PPG
INSIDE MUD WEIGHT (BURST)	-	9.5 PPG	INSIDE MUD WT. (COLLAPSE) -	0	PPG
OUTSIDE MUD WEIGHT (BURST)	-	9.5 PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -	9.5	PPG
FRAC. GRAD. AT SHOE (BURST)	-	14.5 PPG	BIAXIAL LOAD: COLL. [X] BURST [X]	BOUYANCY: YES [ ] NO [X]	

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

1059.8 cu ft (666 sx) Class G cement blended with 40% silica flour and 0.5% CFR-2.

			DESIRED TOP	EXCESS
			Surface	30%
SLURRY VOL. - CU FT / (SLURRY NO.)	1059.8			
SLURRY YIELD - CUBIC FEET/SACK	1.59			
SLURRY DENSITY - PPG	118			
THICKENING TIME - DEPTH SCH/HRS, MIN.	2-3 hrs			
COMPRESSIVE STRENGTH - PSI/HOURS	±2323/8 hrs			

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Run float collar 40' above tie-back sleeve on bottom.
2. Clean and Baker loc threads on bottom 4 joints.
3. Tac-weld top and bottom of collars on bottom 2 joints.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. Run rigid centralizer in middle of bottom joint and one every other tool joint to surface except for top 100'.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

1. Circulate with fresh water.
2. Run top plug only.
3. See attached program for more detail.

PRESSURE TESTING AND LANDING

1. Wait on cement 6 hrs before landing and cutting off 13-3/8" for wellhead.

BOP PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI		
				RAM TYPE	ANNULAR TYPE	ROTATING HEAD
	3000	12-3/8"	See attached drawing	1500	1500	

CASING, CEMENTING AND BOP PROGRAMS

CASING PROGRAM — SIZE: 9-5/8" | DEPTH: 7000' | Liner | WELL: KA2--1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS			
				TOP BURST	BOT. BURST	COLL.	TENSION
3300--5300'	40	L--80	Buttress	2.04	1.97	1.08	6.08
5300--6500'	43.5	L--80	Buttress	2.17	2.30	1.16	13.71
6500--7000'	47	L--80	Buttress	2.30	2.29	1.36	47.74

DESIGN CONDITIONS

SURFACE BURST PRESSURE	-	3000 PSI	OUTSIDE MUD WT. (COLLAPSE)	-	9.5 PPG
INSIDE MUD WEIGHT (BURST)	-	9.5 PPG	INSIDE MUD WT. (COLLAPSE)	-	0 PPG
OUTSIDE MUD WEIGHT (BURST)	-	9.5 PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE)	-	9.5 PPG
FRAC. GRAD. AT SHOE (BURST)	-	14.5 PPG	BIAXIAL LOAD: COLL. [X] BURST [X]		BOUYANCY: YES [ ] NO [X]

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

2000 cu ft (810 sx) of Class G cement blended 1:1 with perlite and 40% silica flour, 4% gel, and 0.65% friction reducer. Tailed with 300 cu ft (192 sx) of Class G cement blended with 40% silica flour and friction reducer. Both slurries to be blended with retardant to give 2-3 hrs pumping time at reservoir temperature. DESIRED TOP: To liner top | EXCESS: 100%

SLURRY VOL. - CU FT / (SLURRY NO.)	2000		300	
SLURRY YIELD - CUBIC FEET/SACK	2.47		1.56	
SLURRY DENSITY - PPG	97.25#/cu ft (13.0 ppg)		118#/cu ft (15.8 ppg)	
THICKENING TIME - DEPTH SCH/HRS. MIN.	2-3 hrs		2-3 hrs	
COMPRESSIVE STRENGTH - PSI/HOURS				

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Run float collar 80' (2 joints) above float shoe on bottom.
2. Weld bottom of collars on bottom 4 joints.
3. Clean and Baker loc threads on bottom 4 joints as well as threads on float collar and shoe.
4. Tac weld top of collars on bottom 2 joints.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. Hand liner 200' up inside 13-3/8" casing with drill pipe.
2. Run rigid centralizers in middle of bottom 4 jonts and then 1 turbo type centralizer every collar to within 200' of top.
3. Run stage collars and external casing packer as in attached procedures.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

1. Attempt to circulate with water.
2. Pump cement and preflush as in attached procedures.

PRESSURE TESTING AND LANDING

1. Wait on cement 12 hrs. Clean out cement from top of 9-5/8" liner. Test lap to 1000 psi. Squeeze lap if necessary to obtain good pressure test.

BOP PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI		
				RAM TYPE	ANNULAR TYPE	ROTATING HEAD
		No change until tie-- back run				

CASING, CEMENTING AND BOP PROGRAMS

CASING PROGRAM — SIZE: 9-5/8" | DEPTH: 3300'± | Tie-Back | WELL: KA2-1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS			
				TOP BURST	BOT. BURST	COLL.	TENSION
0-3300'	40	L-80	Buttress	2.10	1.92	2.34	7.17

DESIGN CONDITIONS

SURFACE BURST PRESSURE	- 3000	PSI	OUTSIDE MUD WT. (COLLAPSE) -	9.5	PPG
INSIDE MUD WEIGHT (BURST)	- 9.5	PPG	INSIDE MUD WT. (COLLAPSE) -	0	PPG
OUTSIDE MUD WEIGHT (BURST)	- 9.5	PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -	9.5	PPG
FRAC. GRAD. AT SHOE (BURST)	- 14.5	PPG	BIAXIAL LOAD: COLL. [X] BURST [X]	BOUYANCY: YES [ ] NO [X]	

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

1140 cu ft (704 sx) Class G cement blended with 40% silica flour and 0.5% CFR-2.

	DESIRED TOP	EXCESS
	Surface	30%

SLURRY VOL. - CU FT / (SLURRY NO.)	1140			
SLURRY YIELD - CUBIC FEET/SACK	1.62			
SLURRY DENSITY - PPG	116			
THICKENING TIME - DEPTH SCH/HRS, MIN.	2-3 hrs			
COMPRESSIVE STRENGTH - PSI/HOURS	±2323/8 hrs			

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Run float collar 40' above tie-back sleeve on bottom.
2. Clean and Baker loc threads on bottom 4 joints.
3. Tac-weld top and bottom of collars on bottom 2 joints.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. Run centralizers in middle of bottom joint and one every other tool joint to surface except for top 100'.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

1. Circulate with fresh water.
2. Run top plug only.
3. See attached program for more detail.

PRESSURE TESTING AND LANDING

1. Wait on cement 6 hrs before landing and cutting off 9-5/8" for expansion spool and blow out preventers.

BOP PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI		
				RAM TYPE	ANNULAR TYPE	ROTATING HEAD
	1500	8-1/2"	See attached drawing	1500	1500	1000

ThermaSource Inc.
P.O. Box 1236 • Santa Rosa, CA 95402

MUD

MUD, LOGGING, WELLHEAD & DIRECTIONAL PROGRAMS

WELL: KA2-1

DEPTH INTERVAL	MUD TYPE	WEIGHT	API FLUID LOSS	YIELD POINT	PH	
0-100'	Gel and water	65#/ft³	---	15	9.0	
100-1000'	Gel and water or air*	70#/ft³	10cc	15	9.0	
1000-3500'	Gel and water or air*	70#/ft³	10cc	15	10.0	
3500-7000'±	Gel and water or air*	70#/ft³	3.2cc	15	10.0	
7000-T.D.	Water or air*	65#/ft³	or 3000 cfm			

REMARKS
*If unable to maintain circulation due to lost circulation, first attempt to aerate system, then attempt to drill with air with rotary bit or air hammer (see attached). If misting is required, it may be necessary to increase air volume 30%. Misting mix should be fresh water mixed with 2-6 gal/10BBls of Magcobar Foamer. Maintain a solution pH above 10.0 to inhibit corrosion. Use Unisteam as outlined in special considerations.

LOGGING

DEPTH INTERVAL	LOG TYPES	LOG SCALES
100-1000'*	Temperature log & logs as directed	1" and 5" = 100'
1000-3500'*	Temperature log & logs as directed	1" and 5" = 100'
3500-7000'	Temperature log & logs as directed	1" and 5" = 100'
7000-T.D.	Temperature log & logs as directed	1" and 5" = 100'
0-T.D.	Samples every 10'	

REMARKS
All logs to be determined by geologist.
*Apply for waiver requiring E-log on these sections of the well.

WELLHEAD

API NOMINAL SIZE	WORKING PRESSURE PSI	TYPE	MAKE
26"	100 psi		
20" S.O.W. x 21-1/4" 2000	2000 psi	*Weld on wellhead	WKM
21-1/4" 2000 x 12" 900	3000 psi	21-1/4" x 12" expansion spool with two 3" 2000 outlets	WKM
12" x 12"	3000 psi	12" 900 Ansi WKM Pow-R-Seal master valve	WKM

REMARKS

DIRECTIONAL OR STRAIGHT-HOLE

Drill hole as straight as possible, taking directional shots every 100'± from 0-7000' and on dull bits after 7000'. 0-3500' maximum deviation to be 5°, maximum rate of change to be 1½° per 100'. 3500-7000' maximum deviation to be 8°, maximum rate of change to be 1½° per 100'. 7000-T.D. monitor without control.

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

GEOTHERMAL WELL DRILLING PERMIT

True/Mid-Pacific Well KA3-1

TO: True Geothermal Energy Company
Central Pacific Plaza
220 South King Street, Suite 868
Honolulu, Hawaii 96813

Your application dated October 30, 1991, for a permit to drill a geothermal well on lands located within the Kilauea Middle East Rift Geothermal Resource Subzone and covered under the State of Hawaii, Geothermal Resource Mining Lease No. R-5 is approved.

Well Designation: True/Mid-Pacific Well KA3-1
Location: TMK 1-2-10:03, Puna, Hawaii
Leased to: Estate of James Campbell (GRML R-5)
Subleased to: True/Mid-Pacific Geothermal Venture
Operator: True Geothermal Energy Company
Ground Elevation: 1,480± ft.
Total Depth: 12,000 feet

You are hereby granted permission to drill the geothermal well described above and in your application in accordance with the Department's Administrative Rules, Chapter 13-183, HAR, and under the following conditions:

(1) All work shall be performed in accordance with the permission and terms of the occupiers of the land, the Drilling and Completion Program submitted with your application, the Department's Administrative Rules (Chapters 13-183 and 13-184, HAR), and all other applicable Federal, State, and County laws, ordinances, rules, and regulations;

(2) The permittee, its successors and assigns shall indemnify, defend, and hold the State of Hawaii harmless from and against any loss, liability, claim or demand for property damage, personal injury and death arising out of any act or omission of the applicant, assigns, officers, employees, contractors and agents under this permit or relating to or connected with the granting of this permit;

(3) The permittee shall observe and comply with all valid requirements of County, State, and Federal authorities and regulations pertaining to the lands and permittee's operations including, but not limited to, all water and air pollution control laws and those relating to the environment;

(4) The applicant shall observe and comply with all requirements and conditions as set forth in the Board of Land and Natural Resources' Decision and Order dated April 11, 1986;

(5) No well shall be sited within 3,500 feet of the eastern boundary of the property line near Kaohe Homesteads, nor within 3,500 feet of the southeastern boundary of the property line near upper Kaimu Homesteads;

(6) The well and bottom-hole location shall be located more than 100 feet from the outer boundary of the parcel of land on which the well is situated, or more than 100 feet from a public road, street, or highway dedicated prior to the commencement of drilling, unless modified by the Chairperson upon request;

(7) The permittee shall notify the Division of Water Resource Management (DWRM), in writing, of the date of the start of work;

(8) Prior to drilling, the permittee shall submit to the Department the bottom-hole target location and direction of any proposed deviation;

(9) All blow-out prevention equipment (BOPE) and cemented casing strings shall be pressure tested before commencing any other operations on the well. Test pressures shall not be less than 600 pounds per square inch nor greater than 1,500 pounds per square inch, and shall be applied for a period of thirty minutes. The results of the pressure tests shall be reported on forms provided by the Department.

If a drop of more than ten percent of the casing test pressure is recorded, the operator shall then run a caliper log and/or other appropriate well test to determine if the casing is defective and if corrective measures will be required before commencing any further operations. The results of the prescribed casing tests and any remedial work conducted shall be submitted to the Department within sixty days after completion;

(10) Class "G" cement shall be used in the casing cementing operations and shall contain a high temperature resistant admix;

(11) A real time monitoring device must be installed for the driller and a pit alarm system should be included with this monitoring device. All toolpushers, drillers, and derrickmen should be schooled in the use of the recommended monitoring equipment.

(12) If changes to the proposed drilling program are contemplated, the permittee shall obtain the Chairperson's approval before executing such changes;

(13) When drilling has reached a depth of not more than 50 feet below sea level, the Department's representative shall be notified, with reasonable time allowed for travel to the site, to witness the retrieval of a representative groundwater sample and the measurement of the static water level. The permittee shall have the sample analyzed by an independent laboratory and have the results submitted to the Department;

(14) During the use of the well for testing, monitoring, production and/or injection purposes, the well and site shall be properly maintained until the well is plugged and abandoned in accordance with the Department's Administrative Rules, Chapter 13-183, HAR;

(15) The permittee shall submit to the Chairperson, the results of any exploration, all drilling and testing records, down-hole surveys of the well, bottom-hole location, date of completion, and a survey of the well location and elevation above mean sea level taken by a Hawaii licensed surveyor within six months after completion of the well;

(16) A well completion report, an as-built drawing of the well, and the location of the well plotted on an U.S.G.S. quad scale map shall be filed with the Department within six months after completion of the well;

(17) The bond covering the well shall remain in full force and effect until the well is properly abandoned and the surface is restored as near as possible to its original condition; and

(18) This permit shall expire 365 days from the date of issuance.

WILLIAM W. PATY, Chairperson

DEC 13 1991

Date of Issuance

cc: Land Board Members
Hawaii County Planning Dept.
DBEDT
Department of Health
OEQC

ThermaSource INC.
GEOTHERMAL CONSULTING SERVICES

TRUE GEOTHERMAL ENERGY COMPANY
KMERZ WELL NO. KA3-1
GEOTHERMAL DRILLING PROGRAM
COUNTY OF HAWAII

Submitted to:

Department of Land and Natural Resources
Honolulu, Hawaii

October 1991

725 Farmers Lane • P.O. Box 1236 • Santa Rosa, California 95402 • (707) 523-2960 • FAX (707) 523-1029

TRUE GEOTHERMAL ENERGY COMPANY
KMERZ WELL NO. KA3-1
GEOTHERMAL EXPLORATION WELL PROGRAM

The following well program is designed to drill and complete a nominal 10,000′ geothermal exploration well in the KMERZ. (See Figure 001) Based on the results of prior drilling, a large degree of flexibility is built into the program. It should be clear that being an exploration well, the casing setting depths and drilling procedures are subject to change at any time. DLNR will be notified and updated as drilling progresses on any changes.

1. Install 30" conductor pipe in 42" hole to 60′ to 100′ or as deep as possible below ground level prior to rotary rig moving onto location. Cement conductor from total depth back to surface with redi-mix cement. If a burial cave or lava tube is encountered when setting the conductor pipe, further investigation is required prior to proceeding. Notify DLNR and consult with archaeologist. If conditions warrant, conductor installation may also be performed with rotary rig.

2. Construct 10′ x 10′ x 9′ deep cellar around conductor pipe with a cemented bottom and stairway exit toward front of rig. See attached Figure 002.

3. Move in rotary drilling rig to drill well. Center rig over conductor pipe and rig up. Drill 42" hole with bucket bit and install 30" conductor, if not installed prior to moving in. Add 30" OD extension to conductor pipe to bring it up under rotary table. Install flow line on conductor pipe to return mud to pits.

4. Notify DLNR upon startup of drilling of a pilot hole. Pick up an 8-1/2" bit on a 26" hole opener or reamer and run into the bottom of the conductor pipe. Center punch 8-1/2" hole and drill 8-10′. Pull out of hole and remove 26" hole opener or reamer. Run 8-1/2" bit and drill to 100′+/-. During the drilling of this 8-1/2" pilot hole progress should be monitored constantly to determine if a lava tube which may contain archaeological artifacts might be encountered directly under the rig. If the bit drops free for more than eight (8) feet then drilling will stop. If this drop occurs the hole will be flushed with clear water and a light source with video camera lowered into the hole to investigate the possibility of any archaeological value. If archaeological value is determined then drilling will stop and the rig moved. If no archaeological value is determined then provisions would be made to continue drilling. Drilling supervisor shall be on drill rig floor throughout complete pilot hole drilling operations.

5. Open 8-1/2" hole to 26" with 26" bit and drill with mud to 800-1000′ depending on geology. Maintain hole as straight as

possible, take drift shots every 100'. Maximum rate of change 1 degree per 100'. Install mud loggers at surface to log entire well from 0' to total depth. Catch three clean and dry samples every 10'.

6. Rig up and run 20" casing to total depth as per attached 20" casing program with 20" stab-in float collar and float shoe on bottom.

7. Once 20" casing has been run to bottom, run in hole with stab-in tool on bottom of drill pipe and stab into float collar. Circulate hole clean with at least two full circulations.

8. Cement 20" casing through drill pipe as per attached program. Circulate cement back to surface between 20" and 30" casing. Observe cement level. If cement falls back in annulus, bring same back to surface with 1" pipe.

9. Wait on cement 8 hours.

10. Land 20" casing. Cut off and remove 30" conductor drilling nipple. Cut off 20" casing and weld on 20" S.O.W. x 21-1/4" 2000 psi wellhead. Install two 3" valves. Install 20" blow out preventer equipment as per attached Figure 003.

11. Test 20" casing and blow out preventer equipment to 1500 psi for 30 minutes.

12. Drill out cement and float collar and float shoe from 20" casing with 17-1/2" bit using mud. Drill 30' of formation and trip to pick up stabilization.

13. Continue to drill 17-1/2" hole as vertical as possible with mud to 3500'+/- as indicated by formation. Directionally survey well at least every 100'. If lost circulation presents severe problems, an aerated mud system may be utilized. Severe loss circulation zones should be cemented off prior to drilling ahead.

14. Once 17-1/2" hole has been completed to casing point, rig up and run logs if indicated by geologic staff.

15. Upon completion of logging program, run in hole with bit and circulate to condition hole for casing.

16. Rig up and run 13-3/8" casing as per attached 13-3/8" casing program and running procedure. If lost circulation presents severe problems during drilling it may be necessary to set 13-3/8" pipe as a liner then tie it back to the surface rather than a full string of casing. See running procedure for alternative options.

17. Cement 13-3/8" casing as per attached program. Circulate cement back to surface between 13-3/8" and 20" casings. Observe cement, if it falls back, bring level back to surface using 1" pipe.

18. Wait on cement 12 hours or until samples are set.

19. Land 13-3/8" casing. Remove 20" blow out preventer stack. Cut off 13-3/8" casing and install 12" x 21-1/4" 900 ANSI expansion spool wellhead with two 3" flanged outlets equipped with 3" 2000 psi wing valves. Install 12" 900 series blow out preventer stack with 12-1/4" bore as per attached Figure 004.

20. Test 13-3/8" blow out preventer stack to 1500 psi for 30 minutes.

21. Drill out all cement, float collar and shoe from the 13-3/8" casing with a 12-1/4" bit using mud. Drill 30' of formation and trip to pick up stabilization.

22. Drill 12-1/4" hole with mud or aerated mud as required by hole conditions to 6000-8000', the 9-5/8" casing point, as indicated by geologic staff. Lock up drilling assembly to maintain direction and angle as straight as possible to casing point.

23. Once 12-1/4" hole has been completed to casing point, rig up and run logs if indicated by geologic staff.

24. Upon completion of logging program, run in hole with bit and circulate to condition hole for casing.

25. Rig up and run 9-5/8" casing as a liner equipped as required with external casing packer located 200-300' from bottom. Hang same using a double slip liner hanger with tie-back sleeve. Run 9-5/8" liner from total depth to hanger located 200' up inside of 13-3/8" casing as per attached 9-5/8" liner program and running procedure.

26. Once liner is hung, circulate hole clean through drill pipe with at least two full circulations.

27. Cement 9-5/8" liner and external casing packer from total depth back up to top of liner lap as per attached cementing program.

28. Once cement is in place, disengage from liner hanger and pull up 60' and circulate out excess cement.

29. Pull out of hole with liner hanging tool and run in hole with 12-1/4" bit and drill out cement from 13-3/8" casing to top of 9-5/8" liner lap. Test lap to 1000 psi only after cement has been in place 12 hours. Squeeze lap area if necessary to

obtain a 1000 psi squeeze pressure.

30. Trip for 8-1/2" bit and drill out excess cement from 9-5/8" liner down to top of float collar. Pressure up and retest 13-3/8" casing, liner lap and 9-5/8" casing to 1000 psi.

31. Drill out cement, float collar and float shoe from 9-5/8" casing using 8-1/2" bit and mud. Drill 30' of formation and circulate to change out mud for water. Re-install rotating head on blow out preventer stack for air drilling if not already installed for the drilling of the 12-1/4" hole.

32. Trip to pick up 8-1/2" stabilization. Drill 8-1/2" hole through production zone to total depth of 9,000'-12,000' using air or aerated water as a drilling medium.

33. Pull out of hole with drill pipe and test well for short term with rig on location.

34. If results appear commercial, pull out of hole and release rig for long production test or proceed ahead with attached 9-5/8" tie-back procedure to complete well with 9-5/8" tie-back, if 13-3/8" casing shows damage or excessive wear. If well test results prove that the flow rate from the well is not commercial then either deepen or redrill to obtain production.

35. Evaluate well and complete with either open hole or 7" slotted liner.

SPECIAL CONSIDERATIONS
AUXILIARY EQUIPMENT THAT SHOULD BE MAINTAINED WITH THE RIG

1. Six pen drilling recorders on drill floor with: a) string weight; b) rpm; c) rotary torque; d) rate of penetration; e) pump pressure; f) exit pressure. Additional real time monitoring of drilling parameters to be considered upon consultation with DLNR Staff.

2. Special rotating head with rubbers, capable of stripping 17-1/2", 12-1/4" and 8-1/2" bottomhole assemblies. Complete with spare rotating head stripper drive bushing assembly. Rotating head should be installed on top of hydril or at least on location, available for installation if necessary. Run cold water continuously on head while producing geothermal fluids.

3. Use tong torque assembly with torque gauge for making up collars to API torque requirements.

4. Temperature should be taken with every directional survey by running a maximum recording thermometer in the survey instrument.

5. Catch drill cutting samples (3 sets) every 10', to be cleaned and sacked.

6. In and out temperatures, both of mud, air or aerated water, shall be recorded in the Tour Reports every 30'. All steam/water entries shall be recorded in the Tour Reports.

7. All lost circulation zones encountered shall be recorded in Tour Book recording both the depth at which the loss occurred, as well as the amount of fluid lost. All flows shall also be recorded giving depth and the amount of increase.

8. Periodic tests may be conducted to determine well potential. Drilling will be stopped and the hole evacuated to check for flow at lost circulation zones.

9. Upon completion, the well will be shut in by closing the lower master valve. The remainder of the blow out preventer equipment will then be removed.

10. Rotary table will be equipped with a torque gauge with visual display for driller.

HYDROGEN SULFIDE MONITORING AND ABATEMENT

Hydrogen sulfide monitoring should be maintained during the drilling of the well. Detectors should be placed on the rig floor, cellar area, and flowline region to detect and announce (with alarms and lights) the presence of hydrogen

sulfide. These monitors are typically provided by and maintained daily by the geothermal data loggers. Proper functioning of these monitors is essential in maintaining a safe working environment.

Hydrogen sulfide abatement equipment and materials, i.e. pumps and caustic soda, should be maintained on location when drilling with lighter than water drilling fluids, i.e. air or aerated mud systems.

Escape breathing equipment, as well as resuscitators shall be available on site with mud logging unit. Fans should also be available on the rig floor to clear H2S contaminated floor areas, making it safer to work.

PIPE AND BLOW OUT PREVENTER INSPECTION

The initial acceptance of drill pipe should be based on an IODC-API Class II specification inspection. All subsequent inspections should discard pipe with 30% wear or greater; i.e., use 30% where Class II states 20%.

The drill pipe should include:

1. Electromagnetic inspection of tubes (Sonoscope or Scanalog).

2. Wall thickness and cross sectional area (ultrasonic or gamma ray).

3. End area inspection (electronic or magnetic particle).

All drill collar end areas should be magnetic particle inspected every 14 days or every 9 days while drilling with production or drilling with air or aerated mud systems.

All BOPs should be inspected for wear by the manufacturer or an authorized agent prior to installation. All BOPs should be tested after installation prior to drilling out cement.

Remind service companies furnishing bottomhole assemblies that their equipment should be magna-fluxed prior to delivery.

AIR EQUIPMENT REQUIREMENTS

Minimum air and pressure requirements are 4500 SCFM at 1000 psig for rotary drilling 12-1/4" hole below 13-3/8" casing.

Minimum air and pressure requirements are 3000 SCFM at 1000 psig for rotary drilling below 9-5/8" casing.

Hook-up lines, air meter, and scrubber, misting pump with minimum capacity of 10 gpm, and operating personnel will be furnished by the air contractor. Use Union Oil's UniSteam corrosion inhibitor while drilling in steam, to be injected into the drill pipe. The mixture for UniSteam is as follows:

Steam lbs/hr	Injection
0-20,000	5 gal UniSteam-10/BBl water
20,000-40,000	10-15 gal UniSteam-10/BBl water
40,000-150,000	20-35 gal UniSteam-10/BBl water
150,000+	40 gal UniSteam-10/BBl water

PROCEDURE FOR RUNNING AND CEMENTING 13-3/8" CASING

1. Drill to casing depth.

2. Circulate for 2-3 hours, two complete circulations to clean hole of cuttings.

3. Pick up excess drill pipe needed to stab into float collar for cementing the 13-3/8" casing.

4. Make short trip and circulate for 1-2 hours.

5. Pull out of hole and rig up to run 13-3/8" casing. Run multi-shot survey while pulling out of hole if necessary. If loss circulation has not been a severe problem in drilling the 17-1/2" hole, then proceed ahead to step 8 and run 13-3/8" casing as a full string. If loss circulation has presented problems, then proceed to step 23 and run 13-3/8" as a liner with tie-back string.

6. Run 13-3/8" casing grades, weights and thread design as indicated on attached detailed sheet with stab-in collar 40' from float shoe on bottom with centralizers located one in middle of bottom two joints and then one every other collar upward omitting any from the top 200'.

7. Set casing in elevators on spider. Do not set casing slips. Drop centralizing ring of 13-3/8" casing inside 20" wellhead. Install return hoses from 20" wellhead to mud pits.

8. Rig up with landing plate on top of 13-3/8" casing. Run drill pipe into 13-3/8" with stab-in sub on bottom. Stab into collar and rig up to circulate. Tie down drill pipe.

9. Circulate for 3 hours, or at least two full circulations, to clean up and cool down hole.

10. Rig up to cement.

11. If loss circulation is a problem, pump 20 BBls $CaCl_2$ water, 10 BBls fresh water, 20 BBls sodium silicate, followed by 20 BBls viscous Geo-Gel mud spacer.

12. Pump cement without any additional spacers. Pump stage 1 consisting of Class G perlite blended 1:1 with 40% silica flour, 3% gel and 0.5% CFR-2. Retard as needed. Pump this cement until you see returns of cement at the surface. If loss circulation has been a problem, the cement may have to be changed to a spherelite blended cement, see Note below.

13. Pump stage 2 cement: Class G cement with 40% silica flour, 3% gel and 0.5% CFR-2. Retard as needed. Pump 200 cu ft of this stage 2 cement. The last 100 cu ft should be staged in: Pump 35 cu ft and shut down for 5-10 minutes, then pump 35 cu

ft and shut down again for 5-10 minutes before pumping last 30 cu ft. Check for fall back in annulus each time. Pull out of stab-in shoe and clear drill pipe, dropping all excess cement from drill pipe on top of float collar.

14. Rig down circulating equipment and pull out of hole with drill pipe.

15. Hook up to 13-3/8" casing elevators and pick up slightly to remove spider, then center 13-3/8" casing in stack.

16. Drain blow out preventer equipment after 30 minutes from the time cement was in place.

17. Wait on cement 12 hours before landing casing. Check for cement fall back in annulus periodically. Bring cement back to surface using 1" pipe if necessary.

18. Cut off 13-3/8" casing. Remove 20" blow out preventer equipment. Install 21-1/4" x 12" 900 ANSI expansion spool, 12" master valve and nipple up blow out preventer equipment as in attached Figure 004.

19. Test blow out preventer equipment to 1000 psi.

20. Change out bottom hole drilling assembly for 12-1/4" tools and run in hole.

PROCEDURE FOR RUNNING & CEMENTING 13-3/8" AS A LINER AND TIE-BACK STRING

1. Follow steps 1-4 above.

2. Pick up 13-3/8" liner. If circulation was never achieved, then a stage collar should be installed at approximately 2000'. Install cement basket type centralizers in the middle of the bottom two joints and one just below stage collar. Install one cement basket type centralizer to be located 20' up inside 20" casing shoe.

3. Run liner in hole and hang same 100' up inside of 20" casing with shoe just off bottom.

4. Attempt to circulate with two times total volume of fresh water. If unsuccessful, then proceed with cement job.

5. Pump 20 BBls CaCl2 water and 10 BBls fresh water, followed by 20 BBls sodium silicate, 20 BBls Geo-Gel flush, then cement slurries for stage 1. Follow stage 1 cement with 200 cu ft of stage 2 cement.

6. Release plugs after stage 2 cement and open cementing ports if stage collar is run.

7. Circulate through stage collar. Repeat preflush prior to pumping cement. Pump stage 1 and stage 2 cement as in prior cement job on bottom section of 13-3/8" liner.

8. Release plugs and displace cement and plugs down hole to close stage collar.

9. Release hanger and pull out of hole with setting tool. Wait on cement for 6 hours.

10. Run in hole with 17-1/2" bit and clean out excess cement, if any, from the top of the 13-3/8" liner.

11. Test lap to 750 psi. If unable to get a test, trip to lay down bit, run in open ended. Squeeze lap with Class G cement blended with 40% silica flour and 0.5% CFR-2 using pipe rams.

12. Re-squeeze until a squeeze pressure is achieved. Fill hole with water.

13. Drill out excess cement with 17-1/2" bit and retest lap to 750 psi.

14. If successful in testing lap, run in hole with 12-1/4" bit and 13-3/8" casing scraper to clean out tie-back sleeve.

15. Pick up 13-3/8" tie-back with float collar located 40' above tie-back stinger on bottom.

16. Run tie-back string in hole and land same in sleeve at hanger.

17. Circulate around with fresh water, then run cement slurry. Use top plug only.

18. Wait on cement 6 hours. If after 6 hours cement is not to surface level in 13-3/8" x 20" annulus, insert 1" tubing and bring it back to surface with cement.

19. Cut off 13-3/8" casing. Remove 20" blow out preventer equipment. Install 21-1/4" x 12" 900 ANSI expansion spool, 12" master valve, and nipple up blow out preventer equipment as in attached Figure 004.

20. Test blow out preventer equipment to 1000 psi for 30 minutes.

21. Change out bottom hole drilling assembly for 12-1/4" tools and run in hole.

NOTE: Spherelite cement should be blended as follows:

Class G cement blended with 40% silica flour, 50 lbs per sack of cement of spherelite, 4% gel, 5% lime, 1.25% CFR-2, and 0.5% Halad-22A.

Cement should be mixed at 82.2#/cu ft (11 ppg). Slurry yield is 3.21 cu ft/sack.

Mixing water requirements are 1.50 cu ft/sack (11.22 gal/sack).

9-5/8" LINER RUNNING PROCEDURE

The drilling program for Well KA3-1 has been written in such a way as to handle all situations that occur during the drilling. Due to the remote location and shipping requirements we must consider all possible hole conditions. These conditions that should be anticipated are listed in order of increasing severity as follows:

1. The 12-1/4" hole is drilled with little or no loss circulation encountered. Due to lost circulation encountered in drilling it would be highly probable that loss of circulation may occur during the cementing of the 9-5/8" liner.
   In this situation where lost circulation has not presented a significant problem during drilling, I feel that a conventional method should be employed in the running and cementing procedure for the 9-5/8" liner. The attached program "PROCEDURE FOR RUNNING AND CEMENTING 9-5/8" LINER WITHOUT EXTERNAL CASING PACKER AND MULTI-STAGE CEMENTER" should be used.

2. The 12-1/4" hole is drilled with air, aerated water or mud, with moderate loss circulation, that is loss circulation encountered in several zones which could be sealed with cement or LCM, or partial loss circulation zones which may take fluid periodically during drilling operations. Probability of lost circulation during cementing is high and should be anticipated.
   In this situation a certain amount of caution should be used in running and cementing the 9-5/8" liner to insure a competent cement job. A 9-5/8" liner utilizing a multi-stage cement collar strategically located could assist in obtaining an adequate cement job. The attached program "PROCEDURE FOR RUNNING AND CEMENTING 9-5/8" LINER WITH MULTI-STAGE CEMENTER" should be used.

3. The 12-1/4" hole is drilled using air or aerated water because of complete loss of circulation during the drilling. Sealing of these loss circulation zones prove to be unsuccessful or extensive causing a great loss of time therefore air or aerated fluid is used to drill the well. Probability of loss circulation during the cement job is high, therefore extreme methods of cementing the liner should be used.
   In this situation where major problems exist in the well, extreme procedures and technologies should be employed to insure an adequate cement job. The attached program "PROCEDURE FOR RUNNING AND CEMENTING 9-5/8" LINER EQUIPPED WITH EXTERNAL CASING PACKER AND HYDRAULIC CEMENTER" should be used.

PROCEDURE FOR RUNNING AND CEMENTING 9-5/8" LINER
WITHOUT EXTERNAL CASING PACKER AND MULTI-STAGE CEMENTER

1. Drill to casing depth at approximately 6000-7000′ dependent on temperature and geology.

2. Circulate for 2-3 hours to clean and cool hole.

3. Pull out of hole.

4. Rig up and run logs as indicated by geologic staff. Wait on bottom with temperature log for 30 minutes before pulling out of hole.

5. Rig down loggers and run in hole with bit and monel to total depth.

6. Circulate for 2 hours and make short trip. Circulate for 1-2 hours after short trip.

7. Pull out of hole and rig up to run 9-5/8" liner. Run additional directional surveys while pulling out of hole if necessary.

8. Run 9-5/8" liner grades, weights and thread design as indicated in detail sheet with float shoe on bottom and float collar two joints up. Centralizers should be located one in the middle of the bottom two joints and then one every to every other collar upward to within 60′ of the hanger. Use T-Bar rigid centralizers totally in bottom portion of the string and then as required in the upper portion. Run casing adjusters at 600′, 1800′ and 3400′ above shoe joint if required.

9. Circulate two full circulations to clean up and cool down well prior to cementing.

   Note: If casing can still be moved after running to bottom then move casing throughout circulation and cementing job and hang after cement is in place. If casing will not move after running to bottom, then hang liner before circulating and cementing job.

10. If loss circulation is encountered, pump 20 BBls of CaCl2 water and 10 BBls of fresh water ahead of 20 BBls of sodium silicate.

11. Pump in 20 BBls of viscous Geo-Gel mud preflush.

12. Pump cement without any water spacers. Pump stage 1: Class G cement and perlite blended at a ratio of 1:1 with 40% silica flour, 3% gel and friction reducer. Retard to give 2-3 hours

pumping time at 350 degrees F. Use 100% excess. If lost circulation is a problem, cement may be required to be changed to a spherelite blend. See note at bottom of this procedure. Pump stage 1 as per precalculated volumes.

13. Pump stage 2: Class G cement blended with 40% silica flour, 3% gel and friction reducer. Retard to give 2-3 hours pumping time at 350 degrees F. Pump 200 cu ft of this stage 2 cement. The last 100 cu ft should be staged in: Pump 35 cu ft and shut down for 5-10 minutes, then pump 35 cu ft and shut down again for 5-10 minutes before pumping the last 30 cu ft.

14. Once all cement has been pumped then rig down circulating equipment, hang liner and pull out of liner hanger with drill pipe and pull up 90' and circulate out excess cement on top of liner top.

15. Wait on cement 12 hours. Run in hole with 12-1/4" bit to top of cement, drill out cement to liner top. Wait a full 24 hours from the time cement was in place or until samples have set before pressure testing lap to 1000 psi surface pressure. Squeeze lap if necessary to obtain a pressure test.

16. Trip to change bits to 8-1/2" and clean out cement from inside of the 9-5/8" liner top.

17. Retest liner lap to 1000 psi surface pressure. Squeeze if necessary to obtain a pressure test.

18. Drill out cement, float collar and float shoe with 8-1/2" bit. Drill 60' of formation with mud.

19. Circulate to clean hole and then displace mud in hole for water.

20. Trip out of hole to pick up stabilization.

21. Run back in hole and aerate water. Drill ahead with aerated water to commercial production or total depth.

NOTE: Spherelite cement should be blended as follows:

Class G cement blended with 40% silica flour, 50 lbs per sack of cement of spherelite, 4% gel, 1.25% friction reducer and fluid loss agent.

Cement should be mixed at 88.3 lbs per cu ft (11.8 ppg). Slurry yield is 3.16 cu ft per sack of cement.

Mixing water requirements are 1.5 cu ft per sack (11.22 gal/sack).

9-5/8" CASING PROPERTIES

L-80, 47 ppf, Buttress, Burst: 6870 psi, Collapse: 4760 psi,
Tension: 1,122,000 lbs.

L-80, 53.5 ppf, Buttress, Burst: 6330 psi, Collapse: 3810 psi
Tension: 1,038,000 lbs.

L-80, 40 ppf, Buttress, Burst: 5750 psi, Collapse: 3090 psi,
Tension: 947,000 lbs.

PROCEDURE FOR RUNNING AND CEMENTING 9-5/8" LINER
WITH MULTI-STAGE CEMENTER

1. Drill to casing depth at approximately 6000 - 8000' dependent on temperature and geology.

2. Circulate for 2-3 hours to clean and cool hole.

3. Pull out of hole.

4. Rig up and run logs as indicated by geologic staff. Wait on bottom with temperature log for 30 minutes before pulling out of hole.

5. Rig down loggers and run in hole with bit and monel to total depth.

6. Circulate for 2 hours and make short trip. Circulate for 1-2 hours after short trip.

7. Pull out of hole and rig up to run 9-5/8" liner. Run additional directional surveys while pulling out of hole if necessary.

8. Run 9-5/8" liner grades, weights and thread design as indicated in detail sheet with float shoe on bottom and float collar two joints up. Centralizers should be located one in the middle of the bottom two joints and then one every to every other collar upward to within 60' of the hanger. Install multi-stage cementer in a strategic location in the liner string. The location of the multi-stage cementer should be such that the bottom portion can be cemented successfully without loss circulation. The upper portion can then be cemented after the bottom has had time to set without any loss circulation during cementing. A probable location is just above the loss circulation zones. If the hole was air drilled a good location would be approximately 1200' above the casing shoe. Use 12" T-bar rigid centralizers totally in the bottom portion of the string and then as required in the upper portion. Run casing adjusters at 600', 1800', and 3400' above shoe joint as required.

9. Circulate two full circulations to clean up and cool down well prior to cementing.

   Note: If casing can still be moved after running to bottom then move casing throughout circulation and cementing job and hang after stage 1 cement is in place. If casing will not move after running to bottom, then hang liner before circulating and cementing job.

10. If loss circulation is a problem then pump 20 BBls of CaCl2 water and 10 BBls of fresh water ahead of 20 BBls of sodium

silicate.

11. Pump in 20 BBls of viscous Geo-Gel mud preflush.

12. Pump cement without any water spacers. Pump stage 1: Class G cement and perlite blended at a ratio of 1:1 with 40% silica flour, 3% gel and friction reducer. Retard to give 4-5 hours pumping time at 350 degrees F. Pump in calculated volume to fill the annulus of the 12-1/4" hole x 9-5/8" liner from the liner shoe to the stage collar with 100% excess, with approximately 200 cu ft of tail cement consisting of Class G cement blended with 40% silica flour, 3% gel and friction reducer. If loss circulation is a problem, cement may be changed to a spherelite blend. See note at the bottom of this procedure.

13. Pump stage 1 cement and drop dart for wiper plug. Displace cement with water. Bump plug and open multi-stage cementer.

14. After the stage collar has been opened then circulate out excess cement. Circulate and cool hole for 2 hours prior to pumping stage 2 cement. Hang liner at this point.

15. Pump in 20 BBls of CaCl2 water and 10 BBls of fresh water ahead of 20 BBls of sodium silicate.

16. Pump in 220 BBls of viscous Geo-Gel mud preflush.

17. Pump in stage 2 cement without any water spacers. Pump Class G cement and perlite blended at a ratio of 1:1 with 40% silica flour, 3% gel and friction reducer. Retard to give 2-3 hours pumping time at 350 degress F. Pump in calculated volume of cement to fill 12-1/4" hole x 9-5/8" liner to lap area without excess. Calculated volume should include a 200 cu ft tail slurry of Class G cement blended with 40% silica flour, 3% gel and friction reducer. Retard to give 2-3 hours of pumping time at 350 degrees F. Displace cement with water.

18. Once all cement has been pumped then rig down circulating equipment and pull out of liner hanger with drill pipe and pull up 90' and circulate out excess cement on top of liner top.

19. Wait on cement 12 hours. Run in hole with 12-1/4" bit to top of cement, drill out cement to liner top. Wait a full 24 hours from the time cement was in place or until samples have set before pressure testing lap to 1000 psi surface pressure. Squeeze lap if necessary to obtain a pressure test.

20. Trip to change bits to 8-1/2" and clean out cement from inside of 9-5/8" liner top.

21. Retest liner lap to 1000 psi surface pressure. Squeeze if necessary to obtain a pressure test.

22. Drill out cement, float collar and float shoe with 8-1/2" bit. Drill 60' of formation with mud or water.

23. Circulate to clean hole and then displace mud in hole for water if necessary.

24. Trip out of hole to pick up stabilization.

25. Run back in hole and aerate water. Drill ahead with aerated water to commercial production or total depth.

NOTE: Spherelite cement should be blended as follows:

Class G cement blended with 40% silica flour, 50 lbs per sack of cement of spherelite, 4% gel, 1.25% friction reducer and fluid loss agent.

Cement should be mixed at 88.3 lbs per sack of cement. Slurry yield is 3.16 cu ft per sack of cement.

Mixing water requirements are 1.5 cu ft per sack (11.22 gal/sack).

9-5/8" CASING PROPERTIES

L-80, 47 ppf, Buttress, Burst: 6870 psi, Collapse: 4760 psi, Tension: 1,122,000 lbs.

L-80, 43.5 ppf, Buttress, Burst 6330 psi, Collapse: 3810 psi, Tension: 1,038,000 lbs.

L-80, 40 ppf, Buttress, Burst: 5750 psi, Collapse: 3090 psi, Tension: 947,000 lbs.

PROCEDURE FOR RUNNING AND CEMENTING 9-5/8" LINER EQUIPPED WITH EXTERNAL CASING PACKER AND HYDRAULIC CEMENTER

1. Drill to casing depth at approximately 6000 - 8000′ dependent on temperature and geology.

2. Circulate for 2-3 hours.

3. Pull out of hole.

4. Rig up and run logs as indicated by geologic staff. Wait on bottom with temperature log for 30 minutes before pulling out of hole.

5. Rig down loggers and run in hole with bit and monel to total depth.

6. Circulate for 2 hours and short trip. Circulate for 1-2 hours after short trip.

7. Pull out of hole and rig up to run 9-5/8" liner. Run additional directional surveys while pulling out of hole if necessary.

8. Run 9-5/8" liner grades, weights and thread design as indicated in attached detail sheet with float shoe on bottom and float collar two joints up. Centralizers should be located one in the middle of bottom two joints and then one every other collar upward to within 60′ of hanger. Use T-Bar rigid centralizers in the bottom portion of the string and then as required in the upper portion. If lost circulation is a problem or the hole has been drilled with air or aerated water then CTC external casing packer should be positioned in string 200-300′ from bottom with Halliburton hydraulic stage cementer located above packer. Run casing adjuster at 600′, 1800′, and 3400′ from shoe joint as required. A T-Bar centralizer should be located above and below packer.

9. Run liner equipment. See attached Pre-Job Recommendations.

   Check all equipment to be run on 9-5/8" liner.
   a. Use Instructions & Operations Sheet TE 7.00381. Measure all parts OD and ID.
   b. Check threads on all tools.
   c. Midway liner hanger running tool. Stinger must be reduced down to 3" OD 2.75 ID and run 10-12.5" below bottom of liner hanger as shown on print TE 7.00378. This is when the liner hanger string is at the bottom of its travel.
   d. Part numbers are given on print TE 7.00377 for tools. ID and OD for SR Plug set is given on print TE 7.00379 OD and OD for HOS Cementer are given on print TE 7.00380.

e. All parts and number should check with prints.
f. HOS Tool has four shear pins that will take 2880 psi over Hydrostatic pressure to open it, two other pins are with the tool. Each pin adds 712.5 psi pressure to shear. Open pressure may be adjusted as needed.

10. Installing equipment onto casing strings. See attached Recommendations During Job for further details.

a. Guide shoe.
b. Centralizers on two joints.
c. Float collar.
d. Centralizers as per program.
e. Casing.
f. CTC Packers 200' off bottom.
g. One joint with centralizer in middle.
h. HOS Cementer.
i. Centralizers as per program - run casing adjusters located 1500' and 3000' from shoe.
j. Casing to top of liner. Fill liner as going in hole.
k. Make up SR Baffle Collar on bottom of liner hanger.*
l. Take O-ring off SR plug set and put on SR Baffle Collar.
m. Make up SR plug set on Baffle Collar and tighten at plug set to Baffle Collar. Be sure all parts are tight.
n. Circulate the liner at 3-4 BPM. Stop and circulate 2-3 times while running in hole with liner assembly on drill pipe.

*Be sure there are no areas of drill pipe on liner hanger less than 2.75 ID.

11. Cement liner in three stages.

a. Calculate volume of cement for bottom stage. (200 ft of 12-1/4" hole and 9-5/8" annulus plus shoe joint volume and volume to inflate CTC Packer).
b. Mix cement for above.
c. Pump cement for 200' annulus and shoe joint. Release first stage dart 809.81266 and pump cement for inflated CTC. (Cement to inflate packer should be Class G with 40% silica flour and friction reducer, no perlite.)
d. Pump 10 BBls spacer then displace with mud at 3-4 BPM until 10 BBls before dart should land in SR lower plug - slow rate to 2 BPM. Pressure should go to 1800 psi and plug release.
e. Displace shut off plug at 5-6 BPM until 30 BBls before plug lands. Then pump at 1-2 BPM.

f. When shut off plug lands in shut off baffle, pressure up to 500 psi and shut down.

12. Inflate CTC Packer with cement. See attached Recommendations During Inflation Sequence for further details.

    a. Check volume of displacement tank.
    b. Increase pressure slowly to 700 psi and shut down.
    c. Increase pressure slowly to 800 psi.
    d. Increase pressure slowly to 900 psi or until tool opens.
    e. Pump in 2-5 cu ft of cement per stage until CTC packer is inflated.
    f. Increase pressure to 1000 psi to close CTC packer.
    g. With pressure at 500 psi, check volume of cement needed to inflate tools.
    h. Pressure up to 2800 psi and open HOS.
    i. Circulate well as needed.
    j. Cement liner as per program. Pump spacer. Pump cement.
    k. Release dart for shut off plug. Pump at 4-5 BPM. Pump 10 BBls spacer - then mud.
    l. Displace to within 10 BBls of plug, slow to 2 BPM.
    m. Pressure to 1950-2000 psi to release plug.
    n. Displace at 4-5 BPM.
    o. When plug lands in HOS, pressure up to 3000 psi to close tool. You may have to go to 3500 psi. Hold pressure for 2 minutes.
    p. Release pressure if holding; back off liner hanger tool.
    q. Come out of hole with tools.
    r. Wait 24 hrs and drill out.

13. Rig down circulating equipment, pull out of hanger with drill pipe and pull up 90' and circulate out excess cement leaving 90 linear ft of cement on top of liner top.

14. Wait on cement for 12 hrs. Run in hole with 12-1/4" bit to top of liner and circulate to clean out excess cement. Wait 24 hrs from the time cement was in place and pressure test lap to 1000 psi. Squeeze if necessary.

15. Trip to change bits to 8-1/2" and clean out cement from inside the 9-5/8" liner top.

16. Retest liner lap to 1000 psi surface pressure. Squeeze if necessary.

17. Drill out cement, float collar and float shoe with 8-1/2" bit. Drill 30' of formation.

18. Circulate and change out mud system for water.

19. Trip to pick up stabilization.

NOTE: Spherelite cement should be blended as follows:

Class G cement blended with 40% silica flour, 50 lbs per sack of cement of spherelite, 4% gel, 1.25% CFR-2, and 0.5% Halad-22A.

Cement should be mixed at 88.3lbs/cu ft (11.8 ppg). Slurry yield is 3.16 cu ft/sack.

Mixing water requirements are 1.50 cu ft/sack (11.22 gal/sack).

CASING PROPERTIES

L-80, 47ppf, Buttress, Burst: 6870 psi, Collapse: 4760 psi, Tension: 1,122,000 lbs.

L-80, 43.5ppf, Buttress, Burst: 7930 psi, Collapse: 6620 psi, Tension: 1,286,000 lbs.

L-80, 40 ppf, Buttress, Burst: 5750 psi, Collapse: 3090 psi, Tension: 947,000 lbs.

PRE-JOB RECOMMENDATIONS

1. In close clearance (1/2"-1") installations:

    a. Run a casing scraper.
    b. Drill open hole section with a stabilized packed hole assembly if possible.

2. In liner installations, notify CTC of type of liner equipment before packers are shipped.

3. Insure that everyone involved understands the Payzone Packer system and specific duties they are to perform.

4. Obtain all pertinent well data, including:

    a. Minimum wellbore restriction (should be 1/2" greater than packer OD).
    b. If casing damage is suspected, run a microscopic caliper and/or casing scraper.
    c. Calipered hole size in zone of interest should not exceed maximum recommended hole size. Use "Hole Size vs. Recommended Inflation Pressure Chart" to set pressure control valve.
    d. If junk has been lost in hole it should be fished or driven to below Payzone setting depth.
    e. Clients maximum allowable surface pressure (burst strength of casing with a safety factor), should be obtained prior to setting shear pin.
    f. If hole size adjacent to end assemblies is more than 1" larger than packer OD run one centralizer above and below each packer.

5. Inspect auxiliary equipment.

    a. Float shoe.
    b. Float collar.
    c. Bottom cement wiper plug (proper size, rupture diaphragm).
    d. Two top cement wiper plugs (proper size, no rupture diaphragm).
    e. Pressure recorder (5000 psi scale if possible).
    f. Chicksan lines.
    g. Cementing head.
    h. Verify that adequate inflation cement is available.
    i. Obtain a dry sample of all cements used on the job.

6. Review primary cementing plans and calculate theoretical bottom hole pressure during cementing operations. If expected pressures approach fracture gradient, pressure anomalies are probable and bottom wiper plug should not be run so that knockoff rod protection stays intact.

7. Calculate displacement volumes. Know at what displacement the following events should take place:

    a. Bottom wiper passes packers (knockoff rods).
    b. Bottom wiper lands in float collar.
    c. First top wiper passes packer.
    d. First top wiper lands in float collar, and
    e. Top of inflation cement (second top wiper plug) relative to upper packer.

8. Total inflation pressure is critical to Payzone Packer performance. Before starting a job know and/or calculate: 1. hydrostatic pressure inside and outside the casing at packer setting depth, 2. pore pressure, 3. fracture pressure, 4. maximum recommended differential inflation pressure from hole size vs pressure chart, 5. resultant effective stress.

    a. Total inflation pressure equals:
        1. Hydrostatic pressure inside casing (packer depth) + Applied surface pressure

        OR

        2. Hydrostatic pressure outside casing (packer depth) + Differential inflation pressure

    b. Differential inflation pressure equals:
        1. Total inflation pressure minus Pressure outside casing (packer depth)

        OR

        2. Applied surface pressure minus Balance pressure

    c. Balance pressure equals:
        1. Surface pressure required to offset "U" tube pressure
        2. Approximated by surface pressure (pumping at 1/4-1/2 BBl/min) just prior to plug bump.

    d. Radial effective stress (Seal Load, Wellbore Support) equals:
    Total inflation pressure minus pore pressure.
    -In all cases the differential inflation pressure must be within the hole size vs differential pressure capabilities of the equipment.
    -For zone isolation the radial effective stress (seal load) should be at least 500 psi and total inflation pressure must be less than fracture pressure.

9. Review casing tally. Re-tally casing during run-in if necessary. This is critical if positioning log is not to be run.

10. Make up casing according to API specifications with proper torque and API pipe dope.

Note: It is extremely difficult to properly inflate packers with a casing leak.

11. Epoxy thread lock should be used on packer/casing connections, float collar, and float shoe.

12. A minimum number of only high quality (API approved) centralizers be run below packer(s). If pipe is to be reciprocated, and hole size adjacent to end assemblies does not exceed packer OD plus 2", spacing between packers and centralizers should be greater than reciprocation stroke. Do not place scratchers in this area.

13. If positioning is critical, packers should be logged into position.

14. Insure that cement has adequate pump time.

15. Inflation cement should have an API water loss of less than 150 cc. Inflation cement must not contain lost circulation material.

RECOMMENDATIONS DURING JOB

1. Verify that external cementing aids (centralizers, scratchers, etc.) are properly installed.

2. Run-in speed 1 ft/sec (may be prudently increased to 2 ft/sec per Steps 3 and 4 below).

3. Monitor returns, if more than 30' of casing is run before receiving full returns - SLOW DOWN.

4. Monitor weight indicator - excessive weight loss during run indicates that run-in speed may be too fast.

5. Pressure test lines before beginning cement job. Repair all leaks no matter how small.

6. Verify that wiper plugs are dropped at proper time in proper sequence.

7. Monitor returns during entire job.

8. Monitor mixing and pumping of inflation cement. Verify volume and weight of inflation cement. Batch mix if possible.

   Note: If inflation cement is not batch mixed, monitor BBl counter, but do not rely on its accuracy. Insist that mix water be accurately measured from tanks and that cement density remains constant and proper. (If cement is mixed at proper weight, mix water volume is an accurate indicator of cement volume.)

9. Insist that plug drop be verified via tattle-tale, flag or radioactive techniques.

10. Monitor displacement volume, pump rate and surface pressure during entire displacement process.

11. Determine balance pressure during last 5 BBl of displacement. (Slow displacement to 1/4-1/2 BBl/min and record pressure.)

12. Required displacement volume will normally exceed theoretical casing volume. If mud is used for displacement, expect up to 6%.

RECOMMENDATIONS DURING INFLATION SEQUENCE

1. When first plug lands in float collar:

2. Open shear valve in first or bottom packer by rapidly applying appropriate surface pressure, i.e. balance pressure plus pressure rating of shear valve. (Monitor volume displaced.) Stop pumps and monitor pressure decline, increase pressure by 200 psi or as needed to open valve. Record volume in displacement tanks.

   NOTES:

   a. Flow rate into Payzone packers is relatively slow (1/4 BBl/min). Therefore, it is generally impractical and not advisable to pump continuously during inflation. The preferred procedure is to rapidly increase surface pressure, stop pumping and monitor pressure decline. When the packer is full, the pressure decline will stop.

   b. The expected pressure response during inflation is a function of several variables. In general the following reduce the distinctiveness of the pressure response.
      1. Increased well depth.
      2. Compressability and volume of fluid within the casing string.
      3. Large diameter casing.
      4. Viscosity of inflation cement.
      5. Small inflation volume.

      For example, the pressure response during inflation of a 9-5/8" packer at 12,000' with 3/4 BBl of 16.4 lbs/gal cement may be non-distinct while inflation of a 5-1/2" packer with 1 BBl at 6000' would be very distinct.

3. When packer is completely inflated (surface pressure remains constant), apply final desired inflation pressure.

   a. Record volume pumped and hold pressure for 5-10 min.

   b. Bleed surface pressure slowly back to balance pressure (and/or point 1a above and record flowback volume.

   c. Release pressure slowly.

Note: In shallow (less than 7000') unconsolidated sands, the hole size often enlarges as the packer re-stresses the sand. In these installations, final inflation pressure should be adjusted or reduced in accordance with hole size.

This may be done by converting inflation volume to equivalent hole diameter and using "Hole Size vs Recommended Inflation Pressure Chart".

THINGS TO AVOID

1. Avoid using bottom wiper plugs whenever possible. This is critical if bottomhole pressures during the cement operation are likely to exceed frac pressure.

2. Avoid using spacer fluids below inflation cement because volumetric error and/or pressure anomalies may result in mud-filled packers.

   Note: The use of lightweight spacer fluids below the inflation cement imposes a hydrostatic differential pressure across the valve collar equal to [Weight of cement in annulus (lbs/gal) minus weight of spacer fluid below packer (lbs/gal)] multiplied by .052 times height of spacer fluid below packer.

3. Do not exceed fracture pressure in isolation installations.

4. If spacer fluids are used as substitues for wiper plugs above inflation cement, increase cement volume to compensate for contamination of the upper 100' of inflation cement.

5. Do not use differential fill equipment because debris may enter casing. Some varieties of differential fill equipment must be opened via applied casing pressure prior to circulation. This is not compatible with our valve system.

6. Insist that liner hanger packoffs not be set prior to packer inflation.

7. Do not spud casing - circulate through bridges.

8. Do not use cement with more than 6% Plaster of Paris or Calseal cement.

9. Do not use loss circulation material in inflation cement.

PROCEDURE FOR RUNNING 9-5/8" TIE-BACK CASING
OPTIONAL

1. Kill well with cold water. Pick up Halliburton 9-5/8" EZSV cement retainer on drill pipe and run in hole to 300' below liner top. Set EZSV at this point.

2. Spot a 50 linear foot thick viscous gel pill on top of EZSV and 50 linear feet of cement on top of gel. Fill hole with water and circulate to cool and clean hole. Make appropriate changes to wellhead assembly.

3. Run 9-5/8" casing scraper to clean out liner tie-back sleeve.

4. Rig up and run 9-5/8" tie-back string to top of liner with float collar 40' (1 joint) above stab-in tool on bottom. Stab-in tool will be equipped with slip. Stab into liner, engage slips on the 13-3/8" and pull up on tie-back to 200,000 lbs to pretension tie-back.

5. Cement tie-back as per attached cementing program. Bring cement back to surface between 9-5/8" and 13-3/8" casing, setting centralizer in 13-3/8" casing head before cementing.

6. Wait on cement 12 hours, then release tension.

7. Land 9-5/8" casing. Pick up 12" blow out preventer stack and install expansion spool (12" 900 x 10" 900) equipped with two 3" flanged outlets with 3" 2000 psi wing valves. Install 10" 900 Master Valve and 10" 900 x 12" 1500 adaptor spool and reinstall blow out preventer stack.

8. Test blow out preventer stack, 10" master valve, expansion spool and 9-5/8" tie-back to 1500 psi.

9. Pick up 8-1/2" bit and drill out excess cement and float collar. Work bit through lap area and retest to 1000 psi. Squeeze if necessary.

10. Drill out cement and clean out gel to top of EZSV.

11. Trip for EZSV picking tool and remove EZSV.

12. Return well to production and retest if necessary, using air to induce well to flow.

13. Lay down drill pipe, remove blow out preventer equipment,and move rig off, releasing rig.

14. Prepare for long term test.

15. Test well.

9-5/8" CASING PROPERTIES

L-80, 40 ppf, Buttress, Burst: 5750 psi, Collapse: 3090 psi, Tension: 947,000 lbs.

FIGURES

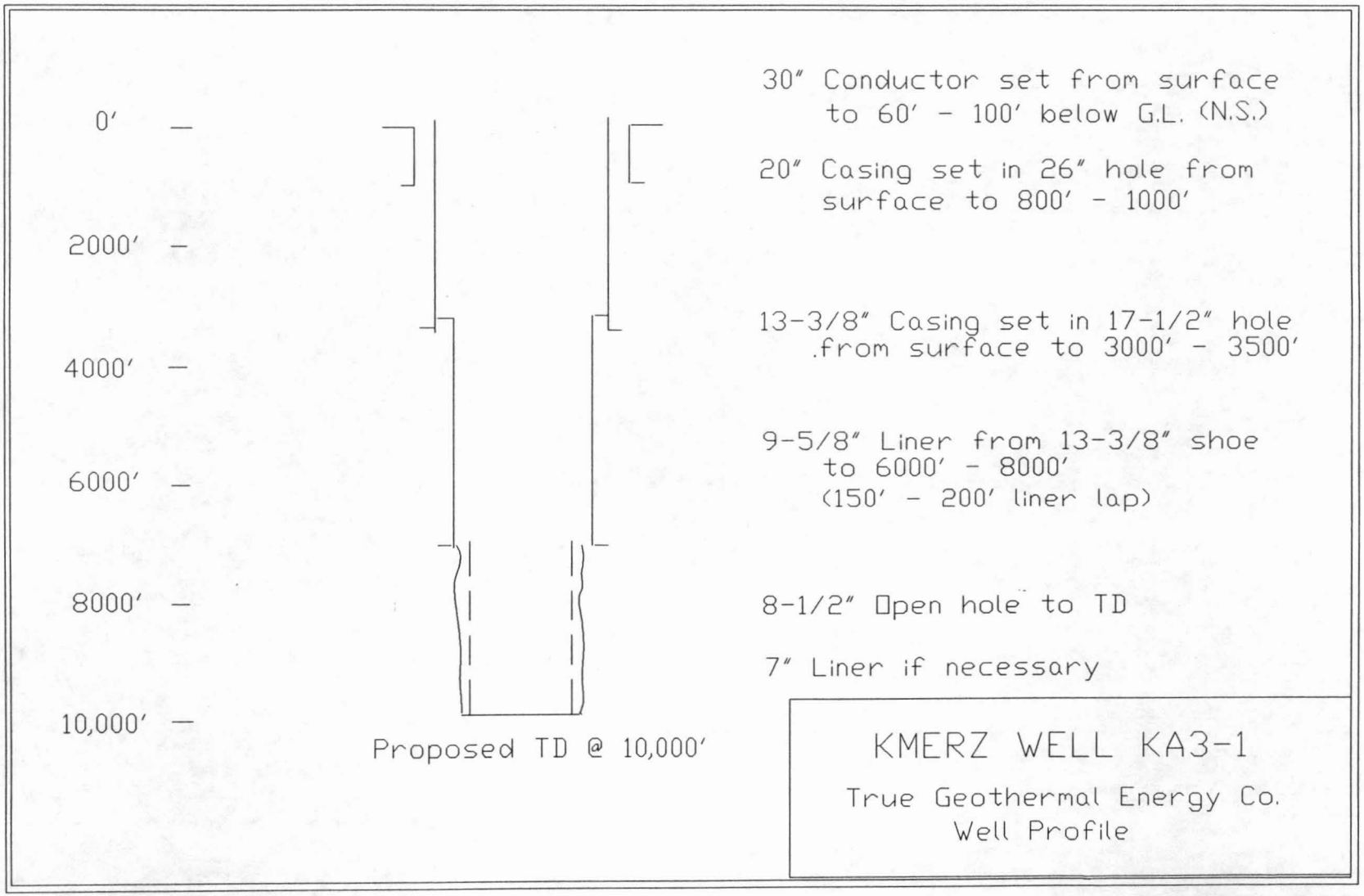
0'
2000'
4000'
6000'
8000'
10,000'
Proposed TD @ 10,000'
30" Conductor set from surface to 60' - 100' below G.L. (N.S.)
20" Casing set in 26" hole from surface to 800' - 1000'
13-3/8" Casing set in 17-1/2" hole from surface to 3000' - 3500'
9-5/8" Liner from 13-3/8" shoe to 6000' - 8000' (150' - 200' liner lap)
8-1/2" Open hole to TD
7" Liner if necessary
KMERZ WELL KA3-1
True Geothermal Energy Co.
Well Profile

FIGURE 001

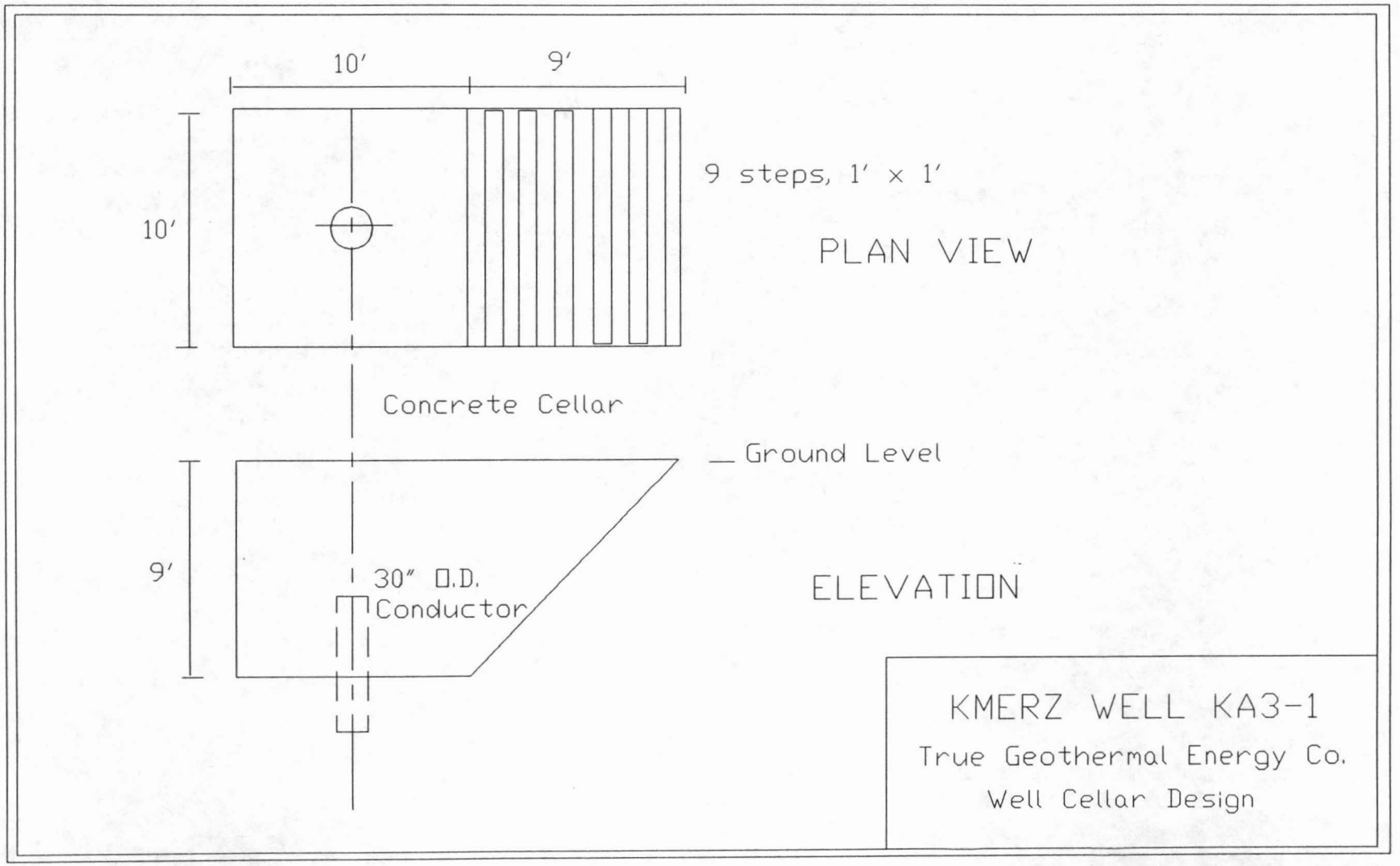
10'
9'
10'
9 steps, 1' x 1'
PLAN VIEW
Concrete Cellar
Ground Level
9'
30" O.D.
Conductor
ELEVATION
KMERZ WELL KA3-1
True Geothermal Energy Co.
Well Cellar Design

FIGURE 002

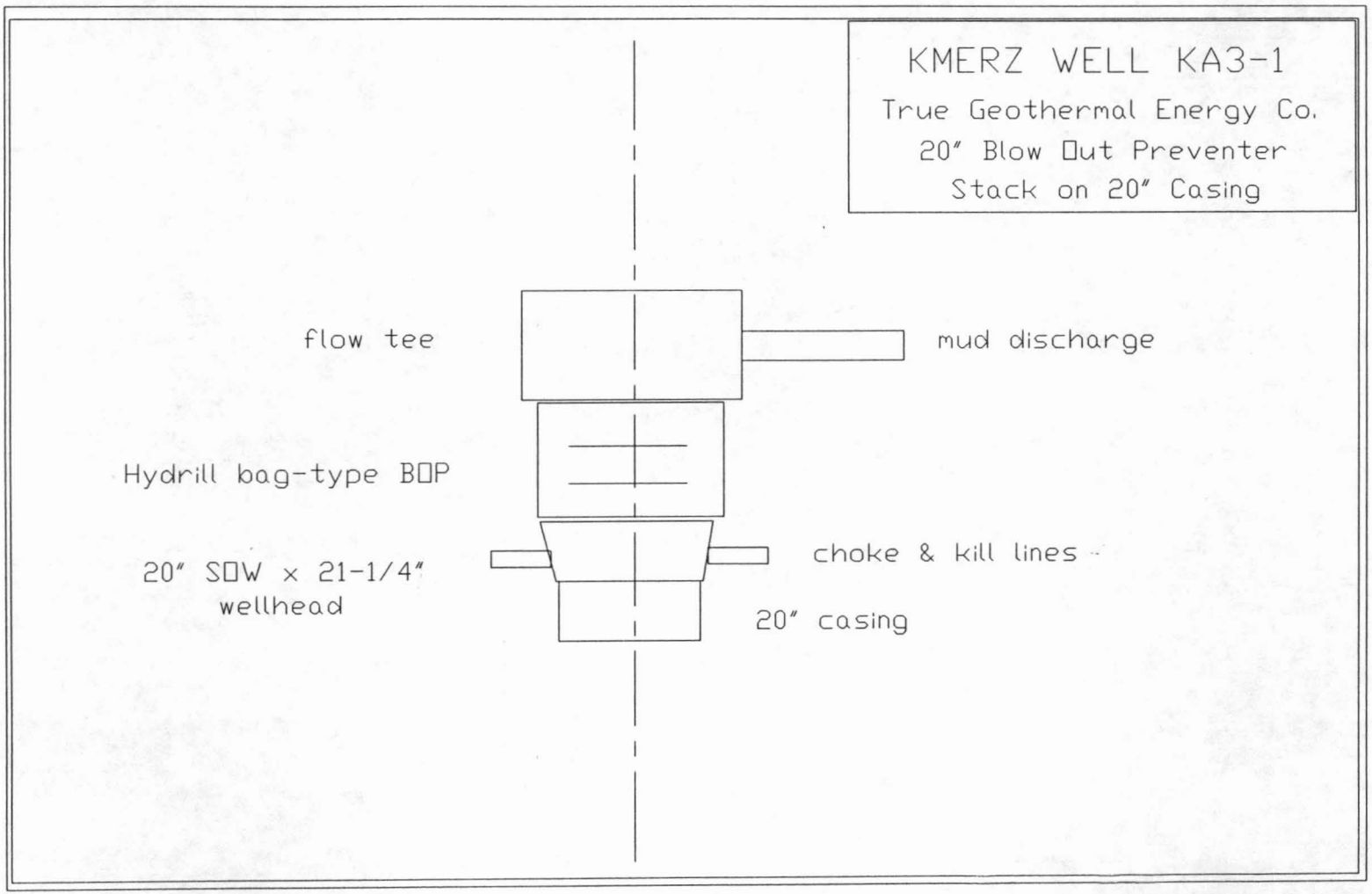
KMERZ WELL KA3-1
True Geothermal Energy Co.
20" Blow Out Preventer
Stack on 20" Casing
flow tee
mud discharge
Hydrill bag-type BOP
choke & kill lines
20" SOW x 21-1/4"
wellhead
20" casing

FIGURE 003

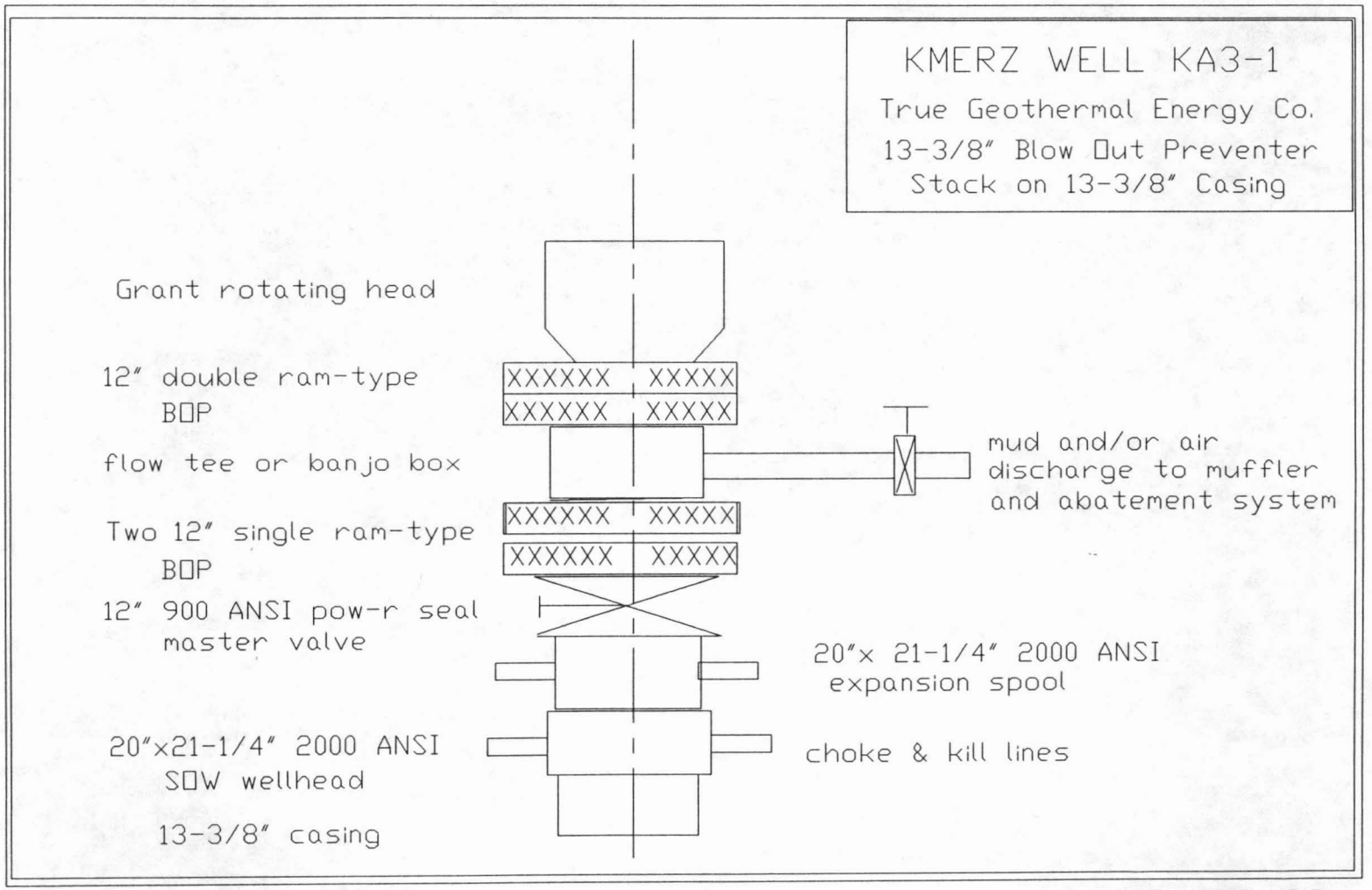
KMERZ WELL KA3-1
True Geothermal Energy Co.
13-3/8" Blow Out Preventer
Stack on 13-3/8" Casing
Grant rotating head
12" double ram-type
BOP
flow tee or banjo box
Two 12" single ram-type
BOP
12" 900 ANSI pow-r seal
master valve
20"x21-1/4" 2000 ANSI
SOW wellhead
13-3/8" casing
XXXXXX XXXXX
XXXXXX XXXXX
XXXXXX XXXXX
XXXXXX XXXXX
mud and/or air
discharge to muffler
and abatement system
20"x 21-1/4" 2000 ANSI
expansion spool
choke & kill lines

FIGURE 004

TABLES

ThermaSource Inc.
P.O. Box 1236 • Santa Rosa, CA 95402

CASING, CEMENTING AND BOP PROGRAM

CASING PROGRAM

SIZE: 20" | DEPTH: 1000' | WELL: KA3-1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS			
				TOP BURST	BOT. BURST	COLL.	TENSION
0-1000'	106.5	K-55	Buttress	3.31	9.21	1.64	9.99+
Casing Properties:							
Collapse-770 psi							
Burst-2320 psi							
Tension-1,683,000 lbs.							

DESIGN CONDITIONS

SURFACE BURST PRESSURE	- 2000	PSI	OUTSIDE MUD WT. (COLLAPSE) -	9.95	PPG
INSIDE MUD WEIGHT (BURST)	- 9.5	PPG	INSIDE MUD WT. (COLLAPSE) -	0	PPG
OUTSIDE MUD WEIGHT (BURST)	- 9.5	PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -	9.5	PPG
FRAC. GRAD. AT SHOE (BURST)	- 14.5	PPG	BIAXIAL LOAD: COLL. ☐ BURST ☐	BOUYANCY: YES ☐ NO ☒	

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

2690 cu ft (838 sx) of Class G cement blended with 50 lbs of spherelite per sack of cement, 40% silica flour, 4% gel, 5% hydrated lime, 1.25% CFR--2 and 0.5% Halad-22A tailed with 400 cu ft (252 sx) of Class G cement blended with 40% silica flour and 3% CaCl2

			DESIRED TOP: Surface	EXCESS: 100%
SLURRY VOL. - CU FT / (SLURRY NO.)	2690		400	
SLURRY YIELD - CUBIC FEET/SACK	3.21 cu ft/sx		1.59 cu ft/sx	
SLURRY DENSITY - PPG	82.2#/cu ft(11 ppg)		118#/cu ft(15.8 ppg)	
THICKENING TIME - DEPTH SCH/HRS, MIN.	2-3 hrs		2-3 hrs	
COMPRESSIVE STRENGTH - PSI/HOURS				

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Stab in float collar located 40' (1 joint) above float shoe on bottom.
2. Weld bottom of collars on bottom 4 joints.
3. Clean and Baker loc threads on float collar and shoe as well as bottom 4 joints.
4. Tac weld top of collars on bottom 2 joints.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. Run rigid centralizer in middle of bottom 2 joints, then one every other tool joint to within 100' of surface.
2. Use centralizer cement baskets as required due to lost circulation.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

1. Stab into float collar with drill pipe. Attempt to circulate with water.
2. Pump 200 cu ft CaCl2 water followed by 100 cu ft of fresh water, 200 cu ft Flo-chek, 200 cu ft Geo-gel, then cement slurries.

PRESSURE TESTING AND LANDING

1. Use 1" pipe in annulus of 20" AND 26" hole to bring cement back to surface if necessary.
2. Wait on cement 8 hours.

BOP PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI		
				RAM TYPE	ANNULAR TYPE	ROTATING HEA
	2000	20"	See attached drawing	1500	1500	

ThermaSource Inc.
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CASING, CEMENTING AND BOP PROGRAM

CASING PROGRAM — SIZE: 13-3/8" | DEPTH: 3500' | Full String | WELL: KA3-1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS: TOP BURST	BOT. BURST	COLL.	TENSION
0-3000'*	68	L-80	Buttress	2.03	1.95	1.51	6.44
3000-3500'**	72	L-80	Buttress	2.08	2.05	1.55	45.83
Casing Properties:*				Casing Properties:**			
Collapse-2260 psi				Collapse-2670 psi			
Burst-5020 psi				Burst-5380 psi			
Tension-1,545,000 lbs				Tension-1,650,000 lbs			

DESIGN CONDITIONS

SURFACE BURST PRESSURE	3000 PSI		OUTSIDE MUD WT. (COLLAPSE)	9.5 PPG	
INSIDE MUD WEIGHT (BURST)	9.5 PPG		INSIDE MUD WT. (COLLAPSE)	0 PPG	
OUTSIDE MUD WEIGHT (BURST)	9.5 PPG		FORM. PRESS. GRAD. AT SHOE (COLLAPSE)	9.5 PPG	
FRAC. GRAD. AT SHOE (BURST)	14.5 PPG		BIAXIAL LOAD: COLL. [X] BURST [X]	BOUYANCY: YES [ ] NO [X]	

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

4257 cu ft (1723 sx) Class G cemetn blended 1:1 with perlite and 40% silica flour, 4% gel and 0.65% CRF-2. Tailed with 300 cu ft (192 sx) of Class G cement blended with 40% silica flour and friction reducer. Both slurries to be blended with retardant to give 2-3 hours pumping time at reservoir temperature. DESIRED TOP: Surface | EXCESS: 100%

SLURRY VOL. - CU FT / (SLURRY NO.)	4257		300	
SLURRY YIELD - CUBIC FEET/SACK	2.47		1.56	
SLURRY DENSITY - PPG	97.25#/cu ft(13.0 ppg)		118#/cu ft (15.8 ppg)	
THICKENING TIME - DEPTH SCH/HRS. MIN.	2-3 hrs		2-3 hrs	
COMPRESSIVE STRENGTH - PSI/HOURS				

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Run stab in float collar 40' (1 joint) above float shoe on bottom.
2. Weld bottom of collars on bottom 4 joints.
3. Clean and Baker loc threads on float collar and shoe as well as bottom 4 joints.
4. Tac-weld top of collars on bottom 2 joints.
5. Run 13-3/8" as full string or liner with tie-back as hole conditions dictate. See attached procedure.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. Run rigid centralizer in middle of bottom 8 joints. Then turbo-type centralizer on every other collar from bottom to within 200' of surface.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

1. If lost circulation is a problem run casing as directed in attached procedure. Use sodium silicate preflush as directoed.
2. Cement through drill pipe.
3. Pump cement of Stage 1 until cement appears at surface, then pump stage 2 cement.

PRESSURE TESTING AND LANDING

1. Wait on cement 12 hrs or until samples have set.
2. Cut & remove 20" casing. Install 12" x 20" expansion spool and blow out preventer stack as in attached drawing.

BOP PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI: RAM TYPE	ANNULAR TYPE	ROTATING HEAD
	3000	12-3/8"	Rotating head & ram	1500	1500	1000

CASING, CEMENTING AND BOP PROGRAM

CASING PROGRAM

SIZE	DEPTH		WELL
13-3/8"	3500'±	Liner	KA3-1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS			
				TOP BURST	BOT. BURST	COLL.	TENSION
900--3000'	68	L-80	Buttress	2.01	1.95	1.49	8.68
3000--3500'	72	L-80	Buttress	2.07	2.05	1.53	45.83

DESIGN CONDITIONS

SURFACE BURST PRESSURE	-	3000 PSI	OUTSIDE MUD WT. (COLLAPSE) -	9.5	PPG
INSIDE MUD WEIGHT (BURST)	-	9.5 PPG	INSIDE MUD WT. (COLLAPSE) -	0	PPG
OUTSIDE MUD WEIGHT (BURST)	-	9.5 PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -	9.5	PPG
FRAC. GRAD. AT SHOE (BURST)	-	14.5 PPG	BIAXIAL LOAD: COLL. [X] BURST [X]	BOUYANCY: YES [ ] NO [X]	

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

3340 cu ft (1041 sx) Class G cement blended with 50# per sack of cement of spherelite, 40% silica flour, 5% hydrated lime, 4% gel, 1.25% CFR-2, and 0.5% Halad-22A, tailed with 300 cu ft (189 sx) of Class G cement blended with 40% silica flour and friction reducer. Both slurries retarded to give 2--3 hrs pumping time at reservoir temperature.

DESIRED TOP 900'± EXCESS 100%

SLURRY VOL. - CU FT / (SLURRY NO.)	3340	300		
SLURRY YIELD - CUBIC FEET/SACK	3.21	1.59		
SLURRY DENSITY - PPG	82.2	118		
THICKENING TIME - DEPTH SCH/HRS, MIN.	2-3 hrs	2-3 hrs		
COMPRESSIVE STRENGTH - PSI/HOURS				

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Run float collar 40' above float shoe.
2. Weld bottom of collars on bottom 4 joints.
3. Clean and Baker loc threads on bottom 4 joints.
4. Tac-weld top of collars on last 2 joints.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. Hang liner 100' up inside 20" casing on drill pipe.
2. Run rigid centralizer cement baskets in middle of bottom 2 joints and one 10' up inside 20" casing and one just below stage collar if a stage is indicated.
3. Run centralizers every other tool joint to bottome of 20" casing.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

1. Attempt to circulate with water.
2. Pump 20 cu ft CaCl2 water and 100 cu ft water, followed by 200 cu ft Flo-Chek the 200 cu ft of Geo-gel, then cement slurries.
3. See attached program for more detail.

PRESSURE TESTING AND LANDING

1. Wait on cement 8 hrs. Clean out cement from top of 13-3/8" liner. Test lap to 1000 psi. Squeeze lap if necessary. Clean out and retest until a test is obtaned.

BOP PROGRAM

API STACK, ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI		
				RAM TYPE	ANNULAR TYPE	ROTATING HEAD
		No change until tie-back run				

CASING, CEMENTING AND BOP PROGRAMS

CASING PROGRAM — SIZE: 13-3/8" | DEPTH: 900'± | Tie-Back | WELL: KA3-1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS			
				TOP BURST	BOT. BURST	COLL.	TENSION
0-900'	68	K-55	Buttress	1.76	1.67	5.04	25.25

DESIGN CONDITIONS

SURFACE BURST PRESSURE	-	3000 PSI	OUTSIDE MUD WT. (COLLAPSE)	-	9.5 PPG
INSIDE MUD WEIGHT (BURST)	-	9.5 PPG	INSIDE MUD WT. (COLLAPSE)	-	0 PPG
OUTSIDE MUD WEIGHT (BURST)	-	9.5 PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE)	-	9.5 PPG
FRAC. GRAD. AT SHOE (BURST)	-	14.5 PPG	BIAXIAL LOAD: COLL. [X] BURST [X]	BOUYANCY: YES [ ] NO [X]	

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

1059.8 cu ft (666 sx) Class G cement blended with 40% silica flour and 0.5% CFR-2.

			DESIRED TOP	EXCESS
			Surface	30%
SLURRY VOL. - CU FT / (SLURRY NO.)	1059.8			
SLURRY YIELD - CUBIC FEET/SACK	1.59			
SLURRY DENSITY - PPG	118			
THICKENING TIME - DEPTH SCH/HRS, MIN.	2-3 hrs			
COMPRESSIVE STRENGTH - PSI/HOURS	±2323/8 hrs			

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Run float collar 40' above tie-back sleeve on bottom.
2. Clean and Baker loc threads on bottom 4 joints.
3. Tac-weld top and bottom of collars on bottom 2 joints.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. Run rigid centralizer in middle of bottom joint and one every other tool joint to surface except for top 100'.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

1. Circulate with fresh water.
2. Run top plug only.
3. See attached program for more detail.

PRESSURE TESTING AND LANDING

1. Wait on cement 6 hrs before landing and cutting off 13-3/8" for wellhead.

BOP PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI		
				RAM TYPE	ANNULAR TYPE	ROTATING HEAD
	3000	12-3/8"	See attached drawing	1500	1500	

CASING, CEMENTING AND BOP PROGRAMS

CASING PROGRAM — SIZE: 9-5/8" | DEPTH: 7000' | Liner | WELL: KA3-1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS			
				TOP BURST	BOT. BURST	COLL.	TENSION
3300--5300'	40	L--80	Buttress	2.04	1.97	1.08	6.08
5300--6500'	43.5	L--80	Buttress	2.17	2.30	1.16	13.71
6500--7000'	47	L--80	Buttress	2.30	2.29	1.36	47.74

DESIGN CONDITIONS

URFACE BURST PRESSURE	- 3000	PSI	OUTSIDE MUD WT. (COLLAPSE) -	9.5	PPG
INSIDE MUD WEIGHT (BURST)	- 9.5	PPG	INSIDE MUD WT. (COLLAPSE) -	0	PPG
)UTSIDE MUD WEIGHT (BURST)	- 9.5	PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -	9.5	PPG
FRAC. GRAD. AT SHOE (BURST)	- 14.5	PPG	BIAXIAL LOAD: COLL. [X] BURST [X]	BOUYANCY: YES [ ] NO [X]	

EMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

2000 cu ft (810 sx) of Class G cement blended 1:1 with perlite and 40% silica flour, 4% gel and 0.65% friction reducer. Tailed with 300 cu ft (192 sx) of Class G cement blended with 40% silica flour and friction reducer. Both slurries to be blended with retardant to give 2-3 hrs pumping time at reservoir temperature.

			DESIRED TOP	EXCESS
RRY VOL. - CU FT / (SLURRY NO.)	2000		300	
SLURRY YIELD - CUBIC FEET/SACK	2.47		1.56	
LURRY DENSITY - PPG	97.25#/cu ft (13.0 ppg)		118#/cu ft (15.8 ppg)	
THICKENING TIME - DEPTH SCH/HRS. MIN.	2-3 hrs		2-3 hrs	
COMPRESSIVE STRENGTH - PSI/HOURS				

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Run float collar 80' (2 joints) above float shoe on bottom.
2. Weld bottom of collars on bottom 4 joints.
3. Clean and Baker loc threads on bottom 4 joints as well as threads on float collar and shoe.
4. Tac weld top of collars on bottom 2 joints.

ENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. Hand liner 200' up inside 13-3/8" casing with drill pipe.
2. Run rigid centralizers in middle of bottom 4 jonts and then 1 turbo type centralizer every collar to within 200' of top.
3. Run stage collars and external casing packer as in attached procedures.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

1. Attempt to circulate with water.
2. Pump cement and preflush as in attached procedures.

RESSURE TESTING AND LANDING

1. Wait on cement 12 hrs. Clean out cement from top of 9-5/8" liner. Test lap to 1000 psi. Squeeze lap if necessary to obtain good pressure test.

LOP PROGRAM

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI		
				RAM TYPE	ANNULAR TYPE	ROTATING HEAD
		No change until tie-- back run				

CASING, CEMENTING AND BOP PROGRAM

CASING PROGRAM

SIZE	DEPTH		WELL
9-5/8"	3300'±	Tie-Back	KA3-1

INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS			
				TOP BURST	BOT. BURST	COLL.	TENSION
0--3300'	40	L--80	Buttress	2.10	1.92	2.34	7.17

DESIGN CONDITIONS

SURFACE BURST PRESSURE	- 3000	PSI	OUTSIDE MUD WT. (COLLAPSE) -	9.5	PPG
INSIDE MUD WEIGHT (BURST)	- 9.5	PPG	INSIDE MUD WT. (COLLAPSE) -	0	PPG
OUTSIDE MUD WEIGHT (BURST)	- 9.5	PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE) -	9.5	PPG
FRAC. GRAD. AT SHOE (BURST)	- 14.5	PPG	BIAXIAL LOAD: COLL. [X] BURST [X]	BOUYANCY: YES [ ] NO [X]	

CEMENTING PROGRAM

SLURRY DESCRIPTION AND PROPERTIES

SLURRY DESCRIPTION (AND NUMBER)

1140 cu ft (704 sx) Class G cement blended with 40% silica flour and 0.5% CFR-2.

		DESIRED TOP	EXCESS
		Surface	30%
SLURRY VOL. - CU FT / (SLURRY NO.)	1140		
SLURRY YIELD - CUBIC FEET/SACK	1.62		
SLURRY DENSITY - PPG	116		
THICKENING TIME - DEPTH SCH/HRS. MIN.	2-3 hrs		
COMPRESSIVE STRENGTH - PSI/HOURS	±2323/8 hrs		

RUNNING AND CEMENTING INSTRUCTIONS

SHOE, COLLAR(S) AND JOINT STRENGTHENING

1. Run float collar 40' above tie-back sleeve on bottom.
2. Clean and Baker loc threads on bottom 4 joints.
3. Tac-weld top and bottom of collars on bottom 2 joints.

CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING

1. Run centralizers in middle of bottom joint and one every other tool joint to surface except for top 100'.

PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.

1. Circulate with fresh water.
2. Run top plug only.
3. See attached program for more detail.

PRESSURE TESTING AND LANDING

1. Wait on cement 6 hrs before landing and cutting off 9-5/8" for expansion spool and blow out preventers.

BOP PROGRAM

API STACK, ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI		
				RAM TYPE	ANNULAR TYPE	ROTATING HEAD
	1500	8-1/2"	See attached drawing	1500	1500	1000

ThermaSource Inc.
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MUD

MUD, LOGGING, WELLHEAD & DIRECTIONAL PROGRAMS

WELL: KA3-1

DEPTH INTERVAL	MUD TYPE	WEIGHT	API FLUID LOSS	YIELD POINT	PH	
0-100'	Gel and water	65#/ft³	---	15	9.0	
100-1000'	Gel and water or air*	70#/ft³	10cc	15	9.0	
1000-3500'	Gel and water or air*	70#/ft³	10cc	15	10.0	
3500-7000'±	Gel and water or air*	70#/ft³	3.2cc	15	10.0	
7000-T.D.	Water or air*	65#/ft³	or 3000 cfm			

REMARKS
*If unable to maintain circulation due to lost circulation, first attempt to aerate system, then attempt to drill with air with rotary bit or air hammer (see attached). If misting is required, it may be necessary to increase air volume 30%. Misting mix should be fresh water mixed with 2-6 gal/10BBls of Magcobar Foamer. Maintain a solution pH above 10.0 to inhibit corrosion. Use Unisteam as outlined in special considerations.

LOGGING

DEPTH INTERVAL	LOG TYPES	LOG SCALES
100-1000'*	Temperature log & logs as directed	1" and 5" = 100'
1000-3500'*	Temperature log & logs as directed	1" and 5" = 100'
3500-7000'	Temperature log & logs as directed	1" and 5" = 100'
7000-T.D.	Temperature log & logs as directed	1" and 5" = 100'
0-T.D.	Samples every 10'	

REMARKS
All logs to be determined by geologist.
*Apply for waiver requiring E-log on these sections of the well.

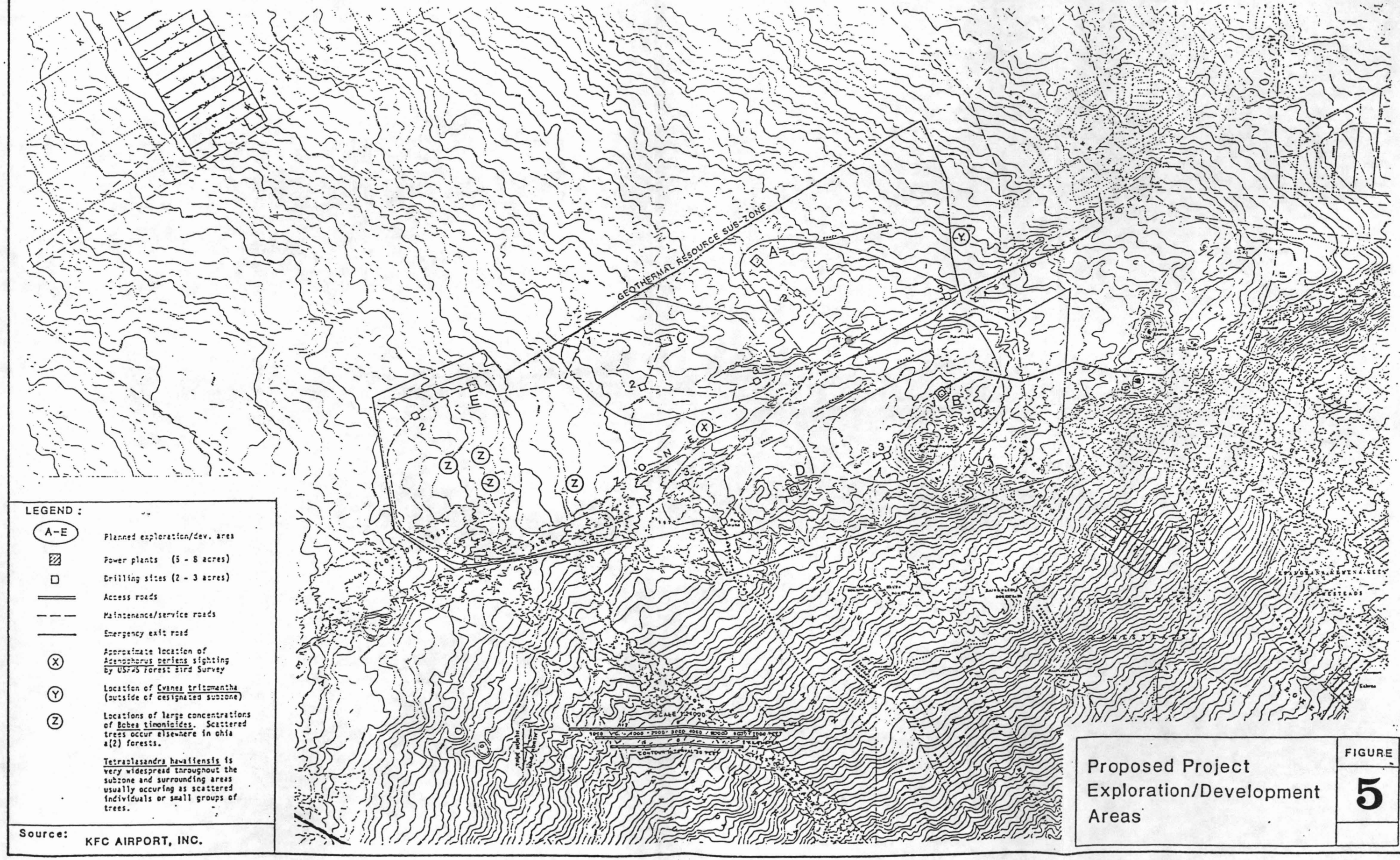
WELLHEAD

API NOMINAL SIZE	WORKING PRESSURE PSI	TYPE	MAKE
26"	100 psi		
20" S.O.W. x 21-1/4" 2000	2000 psi	*Weld on wellhead	WKM
21-1/4" 2000 x 12" 900	3000 psi	21-1/4" x 12" expansion spool with two 3" 2000 outlets	WKM
12" x 12"	3000 psi	12" 900 Ansi WKM Pow-R-Seal master valve	WKM

REMARKS

DIRECTIONAL OR STRAIGHT-HOLE

Drill hole as straight as possible, taking directional shots every 100'± from 0-7000' and on dull bits after 7000'. 0-3500' maximum deviation to be 5°, maximum rate of change to be 1½° per 100'. 3500-7000' maximum deviation to be 8°, maximum rate of change to be 1½° per 100'. 7000-T.D. monitor without control.



LEGEND :

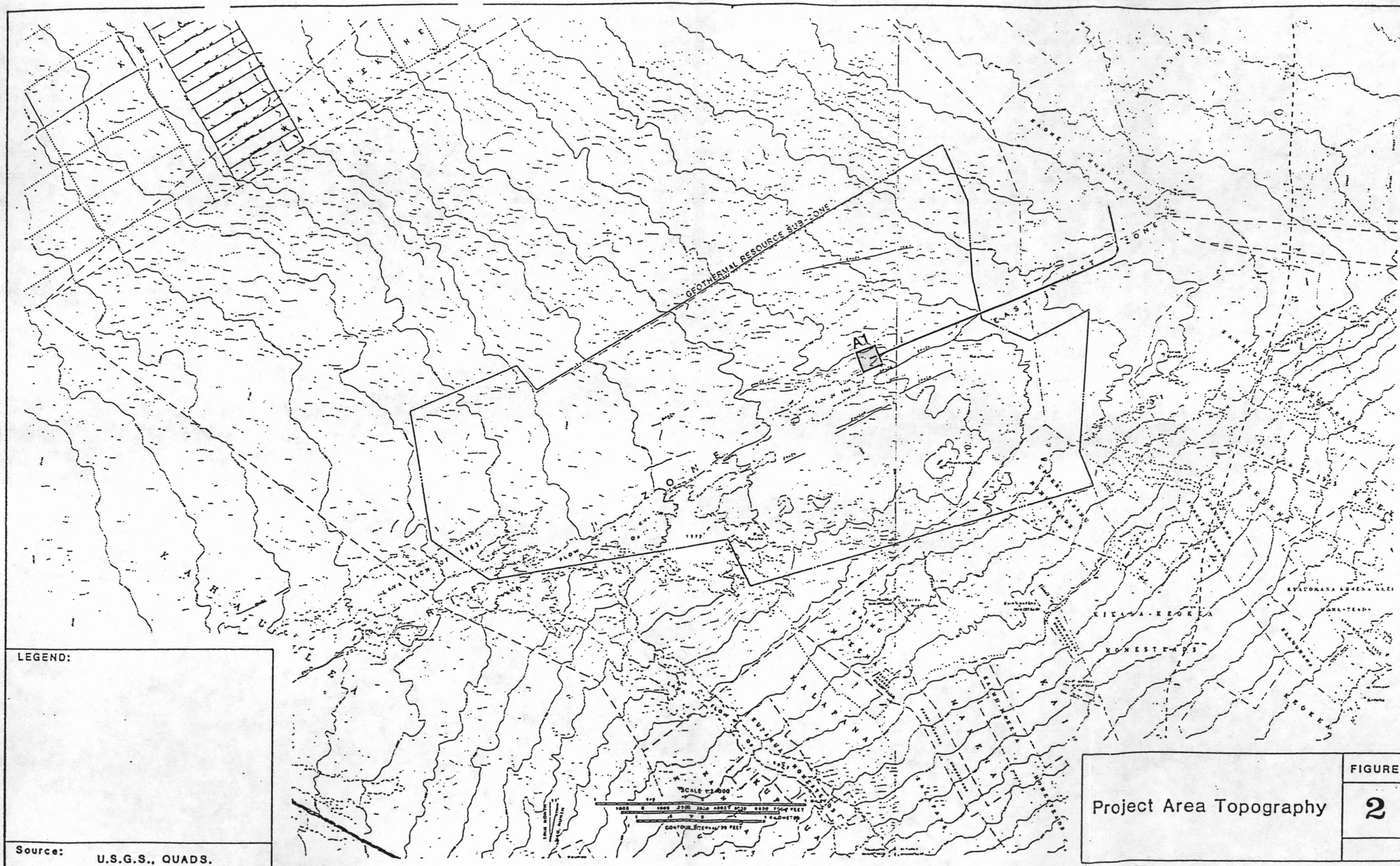
- (A-E) — Planned exploration/dev. area
- ▨ — Power plants (5 - 8 acres)
- □ — Drilling sites (2 - 3 acres)
- ═══ — Access roads
- — — — Maintenance/service roads
- ——— — Emergency exit road
- (X) — Approximate location of Acrocephorus parlens sighting by USFWS Forest Bird Survey
- (Y) — Location of Cyanea tritomantha (outside of designated subzone)
- (Z) — Locations of large concentrations of Bobea timonioides. Scattered trees occur elsewhere in ohia a(2) forests.

  Tetraplasandra hawaiiensis is very widespread throughout the subzone and surrounding areas usually occuring as scattered individuals or small groups of trees.

Source: KFC AIRPORT, INC.

Proposed Project Exploration/Development Areas

FIGURE 5

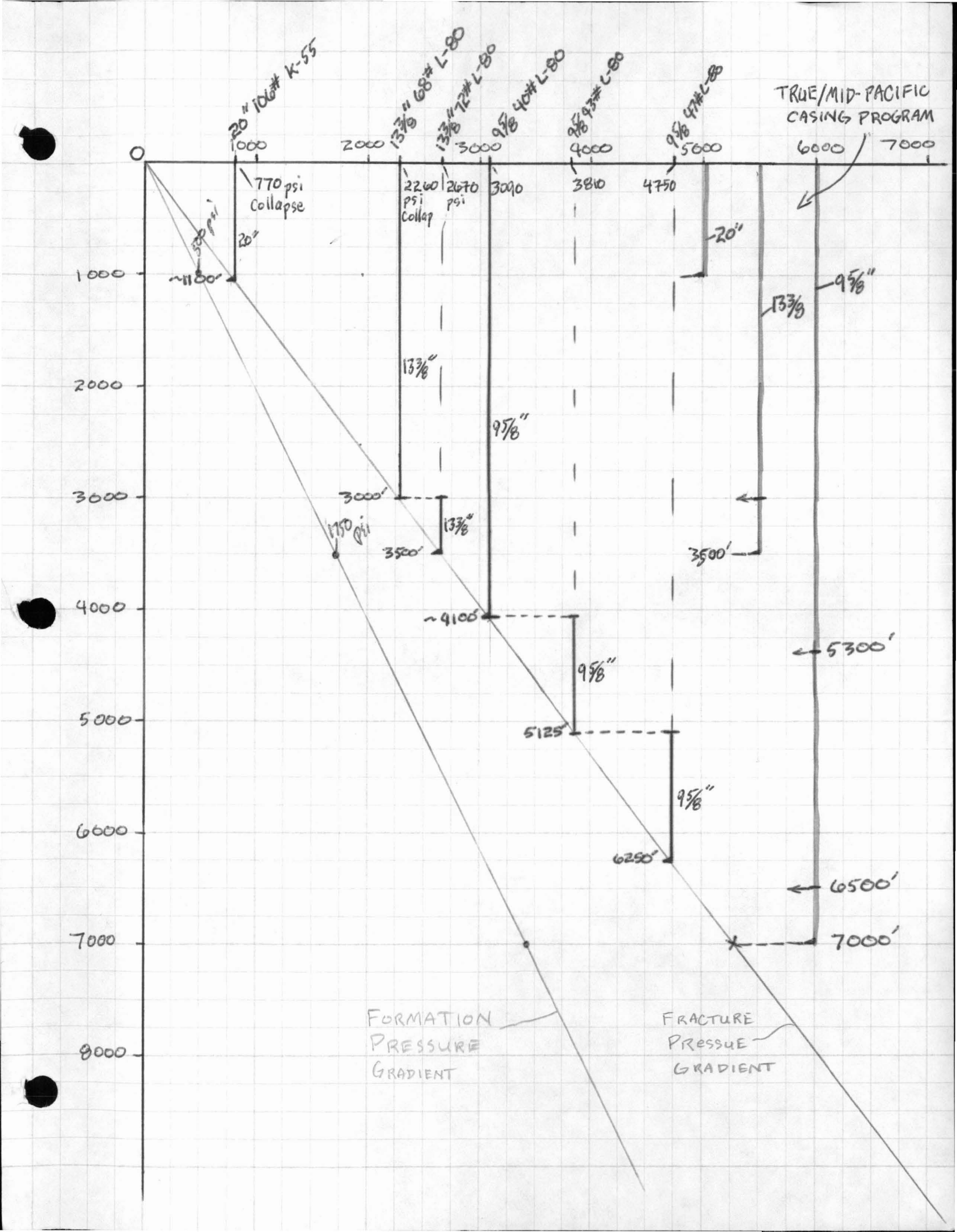


LEGEND:

Source: U.S.G.S., QUADS.

FIGURE 2

Project Area Topography


TRUE/MID-PACIFIC CASING PROGRAM
20" 106# K-55
13 3/8" 68# L-80
13 3/8" 72# L-80
9 5/8" 40# L-80
9 5/8" 43# L-80
9 5/8" 47# L-80
0
1000
2000
3000
4000
5000
6000
7000
8000
770 psi Collapse
2260 psi Collap
2670 psi
3090
3810
4750
~1180'
3000'
3500'
~4100'
5125'
6250'
5300'
6500'
7000'
FORMATION PRESSURE GRADIENT
FRACTURE PRESSUE GRADIENT